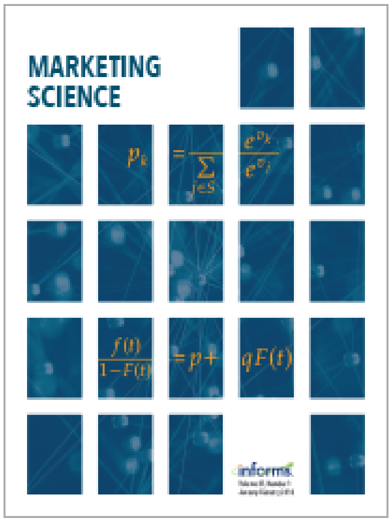

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The Bright Side of Loss Aversion in Dynamic and Competitive Markets

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A well-established phenomenon of consumer buying behavior is that consumers evaluate prices relative to a reference point and exhibit loss aversion; i.e., their propensity to buy is more negatively affected by prices above the reference point than it is positively affected by prices below the reference point. The objective of this paper is to analytically examine how the competitive strategy and profitability of firms are affected by the presence of consumer loss aversion in the price dimension. Although we assume that consumer loss aversion increases consumer propensity to search for lower prices, we find that it does not necessarily lead to lower prices or profits when firms compete over multiple periods and when the consumer reference price in subsequent periods is affected by current prices. Specifically, consumer loss aversion could lead to higher prices and profits when consumer valuation is sufficiently high relative to search costs and the proportion of consumers with positive search costs is in an intermediate range. We also show that when forward-looking firms incorporate the negative effect of price promotions on future profits, the equilibrium range of price promotions may actually increase.

Keywords: game theory; price competition; price promotion; loss aversion; reference price
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If life seems jolly rotten,
There's something you've forgotten....
Always look on the bright side of life.
—Eric Idle, "Always Look on the Bright Side of Life"

1. Introduction

Marketing practitioners and researchers have long recognized that consumer purchase decisions are affected by reference prices and are disproportionately affected more so by perceived losses than perceived gains; i.e., consumers respond more strongly to prices higher than their reference point than to prices lower than their reference point.

A case in point is JCPenney's 2012 ad campaign associated with its decision to reduce the frequency and the amount of price promotions. In an ad characteristic of this campaign, a woman on a shopping trip hysterically screams "No!" when she sees a 67% off promotion that was valid for only yesterday. Then another woman screams "No!" when she passes by the window of a store and notices a 62% off sign for the same jacket she is wearing. The ad continues to show consumers frantically clipping coupons, and a consumer walks away from a line waiting for a store to open after seeing that discounts are (only) 43%. It ends with the announcement of the company's new pricing campaign, "Enough. Is. Enough."[1]

This ad illustrates that JCPenney recognizes that consumers are not only concerned about the value obtained (i.e., the price paid for a given product) but are also distressed by the foregone opportunities of promotions not taken advantage of. Put another way, at least some consumers' purchase decisions depend on their reference prices; these reference prices are lowered by the consumer's exposure to sales promotions, and if the reference price becomes lower than the price the consumer will face, purchase probability declines.

The prominence of this negative side of the reference price—that consumers are more sensitive to the perceived loss of paying above the reference price than to the perceived gain of paying below the reference price—is a well-established phenomenon in the marketing literature and is known as loss aversion (Galanter and Pliner 1974, Kahneman and Tversky 1979).[2]

[1] See *Wall Street Journal* (2012) for more information on this campaign.

[2] In aggregate, loss aversion could be observationally similar to the asymmetric effect of negative versus positive word of mouth on future sales. For example, a price increase by Netflix in 2011 generated fierce emotional reaction from its customers and received considerable media coverage (Wingfield and Stelter 2011). One could imagine that a price cut would not have received as much attention

If loss aversion affects consumer purchase decisions, firms must take it into account when determining their prices and promotions. The objective of this research is to investigate how firms should optimally respond to the presence of consumer loss aversion in the price dimension and how such consumer loss aversion affects industry profitability. In particular, we focus on the effect of consumer loss aversion on the optimal pricing strategy of firms competing over time. We also consider price promotions as they are an important and widely used component of pricing strategy in competitive markets. JCPenney, for example, featured nearly 600 sales in 2011 (*Wall Street Journal* 2012). Granted, this was before the aforementioned change in its strategy, but even the new JCPenney pricing policy involved fewer and better-timed promotions. Because promotions have a strong effect on reference prices, the implications of loss aversion must be carefully considered when designing a promotional strategy.

It is easy to see how loss aversion could negatively affect a firm's profit. If a lower price has been observed in the past, loss aversion implies either a depressed consumer valuation for a product or a higher intention to search for a better deal. Either reaction presses the firm to lower prices to compensate consumers for the perceived loss and, therefore, could lead to lower profits. Taking a step back, expecting this negative effect in the future and attempting to ameliorate it, a firm could be effectively restricted from profitable (short-term) price promotions. Intuitively, constraints on the strategy space also have a negative effect on profitability.

However, in a competitive environment, a constraint on the strategy space could increase profits. There are two reasons for this possibility. First, a firm may benefit from the competitor being constrained. Second, a known-to-the-competitor constraint on the firm's strategy could be beneficial to this firm because of the strategic effect on the competitor's decisions.

The objective of this paper is to better understand how consumer loss aversion in the price dimension affects firms' pricing and promotional strategies as well as profitability over time—and in particular, whether and under what conditions loss aversion may result in (counterintuitively) higher overall profits and/or price dispersion. In other words, we address two basic questions: First, can firms see a bright side to consumer loss aversion for price? Second, and as a practical matter, how should firms adapt their strategy in view of consumer loss aversion?

and consumer response. Another example is the well-known price discrimination case by Amazon in 2000, when consumers were angered by Amazon's attempt to sell DVDs at different prices to different consumers, and many were particularly distressed to find that they had paid a higher price than others (Streitfeld 2000).

To analyze the implications of consumer loss aversion for firms' optimal strategy under realistic assumptions on the marketplace, we develop a two-period model of duopoly competition where consumers need to search to know prices.[3] We assume that the reference price formed from the past-period (realized) prices positively affects consumer intention to search for a better price if the reference price falls below the current price the consumer happens to see.[4] To examine the implications of consumer loss aversion for optimal pricing and promotional decisions of firms, we compare the outcomes of the above model with the outcomes when the consumer loss aversion is assumed away.

Clearly, high reference prices could have a positive effect on profits if consumers value gains, since high reference prices could positively affect consumer valuation or negatively affect their intention to search. Likewise, low reference prices could have a negative effect on profits if consumers are loss averse. The standard argument for the possibility of positive effect of reference prices is based on the benefits of high reference prices resulting from the value of gains. In this paper, we more closely consider the effect of the loss aversion component by itself. In particular, one of the questions we address is whether the aforementioned seemingly negative aspect of reference prices could end up being desirable for the firms. For this objective and to simplify the model, we consider the model without the positive aspect of (high) reference prices.

We show that loss aversion (in the price dimension) has a negative effect on the second period's expected prices and profits but may have a positive effect on the first period's expected prices and profits. To understand the intuition for this possibility and why competition is essential for this result, note that the effect of loss aversion on first-period pricing has direct and strategic (competitive) components. The direct effect is that in foreseeing the negative effect of current price promotions on future profit, each firm optimally promotes less. This effect alone would result in (weakly) higher first-period prices but (weakly) lower first-period profits if the firm were a monopoly. Competition adds a strategic effect—the optimal response of each firm to the direct effect on the competitor's pricing—which increases prices in the first period because each firm is less concerned about the other firm having lower prices.[5] Even more interestingly, we show that the

[3] In markets with price dispersion, one should expect consumer search costs to be important. A significant amount of empirical research has identified positive and significant consumer search costs in various product categories (e.g., Smith et al. 1999, Hong and Shum 2006, Moraga-Gonzalez and Wildenbeest 2008, Honka 2010).

[4] The results are robust to reference prices having only a direct effect on the willingness to pay.

[5] Furthermore, lower price variation also implies lower incentives for consumers to search, which may also imply higher optimal prices and profits for the firm.

increase in first-period average prices and profits could be strong enough to result in higher total profits for each firm and higher price dispersion in the first period.

Examining the conditions under which consumer loss aversion could be beneficial, we find that firms could benefit when the following two conditions are satisfied: First, consumer valuation for the products must be high enough relative to consumer search costs so that equilibrium prices in the absence of loss aversion are constrained by consumer search intention rather than by consumer valuation. Second, the proportion of consumers with positive search cost must be in an intermediate range.

Besides explaining and predicting the effect of loss aversion on firm's profits, our model also helps to identify implications of loss aversion for the optimal pricing and promotional strategies of firms in a competitive environment. Our model helps us to understand the dilemma faced by managers in a competitive market: we show that even when firms fully recognize the negative long-term implications of promotional activities, they (rationally) do not stay away from promotions altogether. We also show that the incentive to restrain from price promotions means that firms can increase their prices as the consumer incentive to search declines. However, these higher prices imply a higher incentive to engage in price promotions. Thus, and somewhat counterintuitively, we find that the equilibrium first-period price range may even increase as a result of consumer loss aversion. Interpreting the top of the price distribution as a regular price and lower prices as promotions, these results can be rephrased as follows: if the regular price is kept exogenously fixed, consumer loss aversion implies optimality of lower/fewer promotions, but keeping the regular price endogenous may produce the opposite effect.

Extending the model to more than two periods, we illustrate how consumer loss aversion may result in ever-increasing price pressure over time with profits declining to zero. Yet we also illustrate, by an extension of the model, how the equilibrium price distribution could exhibit a cyclical pattern of decreasing price over time for some number of periods followed by prices "resetting" to a higher level, after which the decreasing price trend resumes. The latter equilibrium pattern materializes, for example, when the market has an (arbitrarily small) segment of consumers who face search costs but do not exhibit loss aversion behavior or who are loyal to each firm. It is also interesting to note that the timing at which prices reset to the higher level in this model is probabilistic as the competing firms follow mixed strategies in whether to set a high price in hopes that industry dynamic would "reset"; only when both firms set high prices is the dynamic is reset. In other words, when one of the firms (ex ante optimally) decides to charge a higher price to try to reset the industry dynamic, it may (ex post) regret doing so. One could again relate this observation to the example of JCPenney's new strategy and its subsequent reversal.

The remainder of the paper is organized as follows. Section 2 discusses the extant literature related to reference price and loss aversion effects. Section 3 formally defines the model, which is then analyzed in §4. Section 5 further discusses the main assumptions and presents an analysis of several variations of the model for the purpose of understanding the robustness of the model predictions and to speculate how the results could change or be extended to other realistic scenarios. Section 6 concludes.

2. Related Literature

This paper is most closely related to the literature on reference prices and loss aversion. Markowitz (1952) was one of the early researchers to define utility with respect to reference points rather than to the final outcome. Galanter and Pliner (1974) showed that the disappointment people experience from losing some amount of money appears to be greater than the joy they experience from winning the same amount. Kahneman and Tversky (1979) integrated these ideas into the definition of the consumer value function in their prospect theory. According to this theory, the consumer value of an option is defined as a loss or gain relative to a reference point depending on whether the price is higher or lower, respectively, than the reference point. A key postulate of prospect theory is that consumers are more sensitive to losses than to gains, i.e., that consumers are loss averse.

Empirical research with observed consumer purchase data (e.g., Winer 1986, Kalyanaram and Winer 1995) has found consistent evidence of reference price effect in consumer purchase decisions (see further discussion of the robustness of the reference price in Narasimhan et al. 2005). There is also extensive empirical evidence of consumer loss aversion (e.g., Putler 1992, Hardie et al. 1993, Kalyanaram and Winer 1995, Mazumdar et al. 2005).[6] Furthermore, Ho and Zhang (2008) and Ho et al. (2010) presented evidence that managers exhibit loss aversion in pricing and quantity orders as well.

Regarding reference point formation, numerous empirical marketing studies have shown that the

[6] Although some researchers found that the estimates of loss aversion effect are lower if consumer heterogeneity in price responses is accounted for (Krishnamurthi et al. 1992, Bell and Lattin 2000), the loss aversion effect remains in many categories (Bell and Lattin 2000) and within some consumer segments (Krishnamurthi et al. 1992, Bell and Lattin 2000). Therefore, even if loss aversion is not a universal phenomenon, it is important to understand how pricing and promotional strategy should be adapted for markets/categories in which loss aversion is present.

reference price may be affected by past prices (e.g., Winer 1986, Lattin and Bucklin 1989, Bolton et al. 2003), competitors' prices (Hardie et al. 1993, Rajendran and Tellis 1994), and future price expectations (Kalwani and Yim 1992), as well as other factors such as the purpose of the trip (Thaler 1985), frequency of sales (Kalwani and Yim 1992), store characteristics (Biswas and Blair 1991), the amount of information provided by retailers (Lynch and Ariely 2000), and prices paid by other consumers (Feinberg et al. 2002). In some studies, observed past prices were demonstrated to be the strongest determinant of consumers' internal reference price (Briesch et al. 1997, Mazumdar et al. 2005). Reference price effect has been found to influence many aspects of consumers' purchase decisions, such as brand choice (e.g., Kalyanaram and Winer 1995), purchase quantity (Krishnamurthi et al. 1992), purchase timing (Bell and Bucklin 1999), and search behavior (Grewal et al. 1998).[7] In this paper, we concentrate on price and promotion decisions, and therefore, we abstract from nonprice variables. Furthermore, using a two-period model, we focus on the implications of reference price being affected by past price. Note also that firms may and do take an active approach in shaping reference prices through various marketing instruments such as advertising, manufacturer's suggested retail price, display of regular price, or in-store arrangement. These strategies, although important, are beyond the scope of this paper.

Among the analytical literature in marketing examining the implications of reference effects on firm behavior, Greenleaf (1995) studied the optimal dynamic pricing policy of a monopoly when the demand is affected by the reference price, and Kopalle et al. (1996) extended the analysis to multiple products and the competitive case. Both papers show that the reference price effect may lead to high-low pricing in the equilibrium but only when the gain effect of the reference point is greater than the loss effect—in other words, when loss aversion is absent in the aggregate demand function. This finding is based on the model assumption that promotions are not optimal in the absence of reference point effects. Alternatively, we start with the marketing environment where promotions are optimal in a one-shot game and ask whether they would persist and how the pricing strategy and profits would be affected by the presence of loss aversion when firms set prices over time. In this setting, we then find that not only would promotions persist but their magnitude could even increase relative to the case of no loss aversion. Zhou (2011) examined how market competition is affected if consumers are loss averse and the product first reviewed is taken as the reference point. He found that consumer loss aversion in the price dimension intensifies competition whereas consumer loss aversion in the product attributes dimension softens it. In contrast, we show that loss aversion in the price dimension alone could soften competition in a dynamic context.[8] Realistically, product variations between competitors may be common and important to consider in empirical research to fully capture the important characteristics of a marketplace, but a model with homogeneous products allows us to isolate the effect of an important factor in the consumer decision process, i.e., the loss aversion for price.

The idea of loss aversion is also attracting an increasing amount of research in economics. For example, Gul (1991) proposed a theory of disappointment aversion in decision making that accommodated the Allais paradox in particular. Benartzi and Thaler (1995) showed that loss aversion may explain the equity premium paradox.

Turning back to the issue of reference price formation, Kőszegi and Rabin (2006) endogenized reference points by postulating that the reference point equals the consumer's rational (but delayed) expectation of the corresponding outcome given the consumer's strategy. They then extend the notion of Nash equilibrium to the notion of personal equilibrium by requiring that the consumer strategy used to form expectations (and thus the reference point) be optimal given the reference point.[9] They show how this framework explains several empirical findings (e.g., Farber's 2008 data on the daily labor supply of New York taxi drivers). Kőszegi and Rabin (2009) then analyzed how consumers optimally adapt their consumption and spending faced with exogenous shocks over time. Heidhues and Kőszegi (2008) applied the above theory of reference point formation to a static differentiated-product competition with stochastic costs to show how loss aversion may lead to a focal price equilibrium, i.e., may reduce or eliminate the equilibrium price variation. Although the static considerations also imply lower price dispersion in our model, we show that the dynamic considerations may reverse this implication. For the sake of simplicity, in the main model we assume that reference prices are determined by past prices in a reduced form. In §5.3 we show, through a variation of our main model, that the same results can be obtained when consumers form reference prices consistent with the

[7] See Ho et al. (2006) for further discussion of the literature on reference-dependent preferences.

[8] Some recent literature also examined how reference-dependent preferences affect product line design (Orhun 2009) and the incentives to differentiate or imitate (Narasimhan and Turut 2013). Modeling the effects of fairness (e.g., Cui et al. 2007) also implies an assumption on a reference point.

[9] Note that since at the time of consumption/purchase, the consumer expectation of an outcome would equal the outcome, the relevant expectation should be taken at some point in the "recent past" (Kőszegi and Rabin 2006), hence the notion of "delayed expectation" (Kőszegi and Rabin 2009).

theory proposed by Kőszegi and Rabin (2006) but dynamic effects are still present. This model variation illustrates that the possibility of the opposite effect (relative to the main result of Heidhues and Kőszegi 2008) of loss aversion on price dispersion is driven by the dynamic considerations.

Given the marketing environment we study, another closely related stream of research is the analytical studies on price dispersion under competition. Varian (1980) and Narasimhan (1988) modeled oligopolistic price competition when consumers are heterogeneous in their access to information or when each firm has a consumer segment loyal to that firm. Stahl (1989) analyzed a similar model but where uninformed consumers are not exogenously prevented from being informed but rather face a search cost to find the second price. Our model builds on Stahl's (1989) by introducing the consumer loss aversion effect and the dynamic (two-period) game structure.[10]

3. Model

Two undifferentiated firms sell one product each in each of two time periods. Firms have equal marginal cost normalized to 0 and no fixed costs. In each period, a unit mass of consumers has a single-unit demand and values the product at V.[11] With respect to price information, some consumers (proportion β) have zero search cost and thus always observe both competitors' prices. (Another interpretation, which will be helpful for one of the model extensions, is that these consumers know both prices without search by virtue of arriving to the market a little late in the first period and learning prices from earlier consumers). Other consumers (proportion $2\alpha = 1 - \beta$) have a positive cost s to observe prices. For simplicity and consistency with the previous literature, we assume that the first search is free, and thus consumers in the latter segment need to incur s only to observe the second price.[12]

In each of the two periods, the two firms first simultaneously decide what price p_{jt} to charge (j indices firms and t indices time periods). Then, consumers with positive search cost decide whether to search for price, and all consumers decide which product to buy. Firms are forward looking and do not discount future profits.

To model consumer loss aversion, we assume that consumers are affected by a reference price formed during the previous period. In the first period, we consider V as already incorporating the effect of the reference price.[13] In the second period, we assume that the reference price p^r equals the lower of the two prices set by the two firms in the first period. Although, realistically, the reference price could be between the higher and the lower price, assuming it to be equal to the lower one strengthens the loss aversion effect and simplifies analytical tractability. In §5, we also show how the main results could be preserved in a model where the reference price equals the expected price paid, as in the framework introduced by Kőszegi and Rabin (2006). Note that an implicit assumption here is that in the second period, consumers know both prices charged by the two firms in the first period. Although in §5 we argue for the robustness of the model results to the alternative assumption that in the second period consumers only know one of the prices, we believe the assumption of knowledge of both prices realistically captures the notion that new information is learned over time and that it is easier to learn information over time rather than when pressed with the need to purchase. For example, consumers can learn between purchase occasions through promotional mailings, TV ads, or word of mouth at a time when they are not yet in the market to purchase.[14] Note that it is not essential whether the demand in the two periods comes from the same set of consumers as long as the product is not durable or storable across periods. In §5, we discuss an extension of the model in which consumers only know the price(s) they observed in the first period and hence have heterogeneous reference prices in the second period. We show that the main results of the model are robust to this alternative assumption.

Given the reference price, we model loss aversion by assuming that consumers make an economically justified search decision if they observe the price below

[10] Other research examining competitive price promotions includes Lal (1990), Rao (1991), and Lal et al. (1996). Note that price promotions may also be optimal in the absence of competitive rationale. For example, Jeuland and Narasimhan (1985) provided an explanation for temporary price cuts by sellers as a mechanism to discriminate between buyers with more and less intense demand. However, as we will argue below, the surprising effect of increased profits as a result of loss aversion may only be obtained under competition.

[11] It is not essential to our model whether a unit mass of consumers repeat buys in the two periods or the two sets of consumers are separate.

[12] This assumption is not essential in our case. Without this assumption, a fraction of consumers in the segment with positive search costs could abstain from entering the market, but our main results are not affected by this possibility. Furthermore, for high enough V, the first search cost is always optimal to incur and thus has no effect on decisions at all.

[13] Assuming different values for V in different periods does not change the main results as long as the valuation does not depend on the firm's actions under consideration.

[14] Consumers may also have incentives to learn prices when they are not in immediate need of the product but have more time. The motivation for conducting such a post-purchase or between-purchase search, however, could be different from that of a buying decision. For example, the purposes could be to gather information for future purchase, to resolve post-purchase dissonance, or just to satisfy one's curiosity. We do not explicitly model such behavior because it does not add extra vitality to the main findings of the model.

their reference price; otherwise, they search for sure. In other words, observing a price higher than the reference price incentivizes consumers to continue searching.[15] Because we assumed that in the gain domain, consumers behave as if reference price has no effect, we have ruled out the positive effect of reference prices on consumer behavior. We do this for several reasons. First, the extant empirical and behavioral research argues that losses have a stronger effect on consumer behavior. Second, the loss and gain effects are separate; considering them one at a time in an analytical model is useful to more clearly see the implications of each. Third, investigating the strategic implications of consumer loss aversion requires comparing the current model with a model in which consumers are not loss averse (i.e., equally sensitive to losses and gains). Since the difference between the two models should only lie in the negative domain, the current assumption best serves this purpose. Finally, one of our goals is to see whether and under what conditions the negative aspect of reference price (i.e., the one in the domain of losses) could be beneficial to firms. It is clear that the positive aspect (when the prices are in the domain of gains) could be beneficial. Focusing on just the negative domain of the effect allows us to disentangle the two forces and more effectively address our research objectives.

4. Analysis

We use subgame perfect Nash equilibrium as the solution concept and thus solve the game through backward induction. Let $F_{jt}(p)$ denote the cumulative distribution function (CDF) of the equilibrium price distribution of firm j in period t, and let $[\underline{p}_{jt}, \bar{p}_{jt}]$ denote the support of $F_{jt}(p)$. Note that a pure price strategy (i.e., one without promotions) would correspond to $\bar{p}_{jt} = \underline{p}_{jt}$. Since the two firms are symmetric and their equilibrium profits and price distributions also turn out to be the same (i.e., asymmetric equilibria do not exist), we will sometimes omit the subscript indexing firms from the profit and price notation and use the subscript to refer to the time period. The following subsection derives the outcomes of a benchmark model where consumer loss aversion does not exist, §4.2 derives and discusses the optimal strategies in the second period of the main model, §4.3 analyzes the first period, and §4.4 derives the implications of consumer loss aversion by comparing the outcomes of the main and benchmark models. Section 5 discusses the importance of the model's main assumptions for the results and considers a number of model modifications to establish robustness and extend the implications to other market settings.

[15] In §5, we show that similar results can be obtained when loss aversion affects consumer utility directly.

4.1. Benchmark: A Model Without Consumer Loss Aversion

Because we are interested in the effect of loss aversion, let us first consider a benchmark model that differs from the main model only in that consumers do not exhibit loss aversion. In this model, consumers make economically justified search decisions for all prices and hence do not have asymmetry in their response to prices above and below their reference price. This implies that past prices do not matter; thus, the model reduces to a twice-repeated static game in which firms compete on price and consumers have heterogeneous search costs. Although the analysis is essentially the same as in Stahl (1989), it may be useful to briefly recap the forces at play.

Consider first the consumer strategy. Consumers with zero search cost know both prices and therefore buy from the firm with the lowest price (as long as it is below V).[16] Consumers with search cost s look first at one price. Half of them observe the price of firm 1 and the other half observe the price of firm 2.[17] Having observed one price p_j, a consumer with positive search cost needs to decide whether the benefit of discovering the other price p_{3-j} justifies the search cost s. If the consumer decides to search, she then buys at the lowest price.[18] Otherwise, she buys at the first store visited (if the price is below V).

Clearly, if a consumer prefers to search after observing a certain price, she will also search if she observed any higher price. If consumers search when observing the highest price possible in equilibrium, they never come back to the store, and thus the firm setting the highest price possible in equilibrium receives zero profit. Thus, the highest price should be such that consumers do not search. Therefore, consumers with positive search do not search when observing any price in the equilibrium price distribution.

Let $\bar{p}^b$ be the highest price in the equilibrium price distribution. Then, similar to Varian (1980) and Narasimhan (1988), one derives the equilibrium price

[16] Because of the absence of mass points in the price distribution, what happens in the event of a price tie is inconsequential for the firms' pricing strategy and profits. Yet one can postulate that in the event of a tie, the demand is split equally.

[17] There are several ways to justify this conclusion. The most direct one is to assume a random search technology. However, such an assumption is not necessary because the only equilibrium where consumers strategically select where to search first is one in which the first searches are equally split between the two firms. This is because the firm with a higher proportion of first searches (if such a firm exists) will set a higher price, on average, which will make it strictly optimal for consumers to search first at the other firm.

[18] Since in equilibrium consumers will end up not searching, requiring them to pay an additional s if they went to another store only to come back and purchase from the first store does not change any of the results.

distribution to be symmetric and have the following CDF with support on $p \in [\underline{p}_b, \bar{p}_b]$:

$$F_b(p) = \frac{(1-\alpha)p - \alpha \min\{V, V_s\}}{\beta p} \quad \text{with} \quad \underline{p}_b = \frac{\alpha}{1-\alpha}\bar{p}_b. \tag{1}$$

Furthermore, since the equilibrium price distribution does not have mass points, at the highest price possible in equilibrium, the binding constraint comes from consumer valuation or the no-search condition $s > E(\bar{p}_b - p)$ (otherwise, a price a little higher than $\bar{p}_b$ is strictly better than $\bar{p}_b$). Thus, $\bar{p}_b = \min\{V, V_s\}$, where V_s is the solution of $s = E(\bar{p}_b - p)$ for $\bar{p}_b$; i.e.,

$$s = \int_{(\alpha/(1-\alpha))\bar{p}_b}^{\bar{p}_b} (\bar{p}_b - p)\, dF_b(p). \tag{2}$$

Solving the above equation for $\bar{p}_b$, we obtain

$$V_s = \frac{\beta}{\beta - \alpha \ln(1/\alpha - 1)} s. \tag{3}$$

The equilibrium profit of each firm is $\pi_b = \alpha \min\{V, V_s\}$ in each period.

An important insight from the above analysis is that for $V > V_s$, the equilibrium profits and the price distribution are determined by consumers' incentive to search for a better price. This means a change in the market that reduces the expectation of promotions also allows firms to increase prices by reducing the benefit of search. Naturally, this is only possible when the highest price is not constrained by V. As we will see in the following sections, the ability to raise prices in the first period (when $V > V_s$) leads to the possibility that total profits of firms across the two periods increase.

4.2. Second-Period Pricing

The second-period game is similar to the one in the benchmark model. The difference is that if the price exceeds the reference price, consumers search. Therefore, $p < p^r$ is added to the no-search condition, and we obtain that the equilibrium second-period price distribution and expected profits are defined as in the following lemma.

Lemma 1. *Suppose second-period consumers have a reference price p^r. Then in equilibrium, firms set second-period prices according to the following distribution:*

$$F_{j2}(p) = F_2(p) = \frac{(1-\alpha)p - \alpha\bar{p}_2}{\beta p}, \quad \text{where } \bar{p} = \min\{p^r, V, V_s\}, \tag{4}$$

and have the expected second-period profits of $\pi_2 = \alpha\bar{p}_2$ each.

Proof. For a complete proof, see Web Appendix A (available as supplemental material at http://dx.doi.org/10.1287/mksc.2014.0847). □

Lemma 1 quantifies the short-term effect of consumer loss aversion and the previously formed reference price. When the reference price is high enough, the equilibrium in the second period is the same as that in the model without loss aversion. This is due to the assumption that consumers are not affected by gains any more than they rationally should be. On the other hand, when the reference price is lower than $\min\{V, V_s\}$, the equilibrium price distribution is "cropped" by the reference price p^r. The intuition for this is that a lower reference price induces consumer search for lower prices, which intensifies price competition between firms. The above lemma also quantifies the negative effect of reduced reference prices as it states how the equilibrium profits of firms decrease as the reference price decreases.

Given the downward pressure on prices, one could speculate that if the reference price decreases, the price range would be getting compressed to the lower part of the price distribution. However, whereas the direct effect of reference prices on consumer behavior is evident only through the potential prices above the reference price, it is clear from Equation (4) that the effect of reference prices on pricing extends to the lower prices so that the whole distribution of prices shifts downward. We summarize this result as the following proposition.

Proposition 1. *Lower reference prices restrict the ability of firms to obtain demand from higher prices and, in equilibrium, lead to stronger promotions, i.e., to a downward shift of the lower limit of the optimal price range.*

Proof. See Web Appendix A. □

The intuition for this result is that as firms' profitability is constrained by the reference price for prices at the high end of the equilibrium price range, lower prices become more attractive. The competition for demand at lower prices then drives prices down even further. Note that this result is driven by the assumption that the reason for price promotions is that firms fight for a segment of consumers who are indifferent between the two firms and are knowledgeable about prices (or have zero search costs; e.g., they just like to shop). Therefore, this result would not hold, for example, if the price dispersion is caused purely by stochastic costs.

After examining the effect of consumer loss aversion on firms' pricing and profit in the second period, we now turn to the solution to the first-period pricing game.

4.3. First-Period Pricing

In the first period of the model, consumers do not have to account for future decision making in their first-period decision because, by assumption, they cannot forward buy or delay product purchase. Consequently, in the first period, consumer strategy will be similar to the one in the model without loss aversion. Specifically, consumers with zero search cost will always observe both prices and buy from the firm with the lower price, and consumers with search cost s will observe one price for free and decide whether to search further based on whether they expect that the benefit of having a second price quote exceeds the search cost s. Because consumers' expectation of the benefit of search is consistent with the equilibrium prices, their first-period decisions (on search) are indirectly affected by the presence of the second period and the second-period consumer loss aversion.

The firms' decision is different from the one in the second-period pricing game. Because second-period prices and profits are affected by the reference price determined in the first period, firms need to take into account the effect of their first-period pricing decision on both the demand and the competitor's price in the second period. Without loss of generality, consider the first-period pricing problem of firm 1. Suppose firm 1 expects firm 2 to price in the first period according to the distribution $F_{21}(p)$ (where 1 stands for the first period and 2 stands for firm 2). Then, the objective of firm 1 is to choose p_{11} to maximize the following profit function:

$$\pi_1^s(p_{11} \mid F_{21}(p)) + \int_{p_{11}}^{\bar{p}_{21}} \alpha \min\{p_{11}, V_s\}\, dF_{21}(p) + \int_{\underline{p}_{21}}^{p_{11}} \alpha \min\{p, V_s\}\, dF_{21}(p). \tag{5}$$

The first term in the equation is the first-period profit of firm 1 given that firm 2 prices according to distribution $F_{21}(p)$. The remaining terms capture the future profit of firm 1 and reflect the dynamics of the model. The second term captures firm 1's profit in the second period if $p_{11} < p_{21}$, and therefore, p_{11} becomes the reference price. The last term captures its profit if the opposite is true, i.e., when the first period's price of firm 2 is lower and p_{21} becomes the reference price. It is easy to see that the sum of the latter two terms increases in p_{11}. This means that the expected profit of a firm increases in its current price and leads to less aggressive pricing in the first period (i.e., higher prices). When consumers are loss averse, firms have to trade off between immediate and future profit.

Although firms now have an additional disincentive to reduce price in the first period, the first-period game still has no pure strategy equilibrium. The intuition is that when prices are equal, each firm obtains demand from half of the market. Given this, if one firm lowers price by an arbitrarily small amount, it will capture the whole market in the current period but lose some profit in the future period. Because the incremental profit in the current period is discontinuous but the change of profit in the second period is continuous, firms will find it optimal to undercut rather than to charge equal prices.

To solve for equilibrium in the first period, we need to consider $p < V_s$ and $p > V_s$ (where V_s is defined by Equation (3)) separately, since firms' pricing incentives are different in these two regions. When $p < V_s$, the reference price p^r in the second period is below V_s, and thus, the expected second-period profit is equal to αp^r. Equation (5) then simplifies to $p + [1 - F_1(p)](1-\alpha)p + \int_{\underline{p}_1}^{p} \alpha t\, dF_1(p)$ (where the subscript indicates that the firm is suppressed). This means the equilibrium price distribution in this region has the following form:

$$F_{j1}(p) = F_1(p) = \frac{1 - (\underline{p}_1/p)^{(1-\alpha)/\beta}}{1-\alpha} \quad \text{for } p < V_s, \tag{6}$$

where $\underline{p}_1$ is the lower bound of the equilibrium price distribution in the first period. When $p > V_s$, the price does not affect the second-period profit because if it determines the reference price p^r, the reference price is higher than V_s and therefore does not enter the second-period price distribution defined in Lemma 1; if it does not determine the reference price, it also has no effect on second-period profits. Therefore, in this case, the profit maximization problem is similar to the benchmark case and leads to

$$F_{j1}(p) = F_1(p) = \frac{(1-\alpha)p - \alpha\bar{p}_1}{\beta p} \quad \text{for } p > V_s, \tag{7}$$

where $\bar{p}_1$ is the upper bound of the equilibrium price distribution in the first period.

The equilibrium first-period pricing is summarized in the following lemma.

Lemma 2. *The equilibrium prices in the first period of the main model are in symmetric mixed strategies $F_1(p)$ with an upper limit $\bar{p}_1$ and lower limit $\underline{p}_1$.*

1. *If $V \geq V_s$, then*

$$F_1(p) = \begin{cases} \left(\dfrac{1}{1-\alpha} + \dfrac{\alpha^2 V_s - \alpha(1-\alpha)\min\{V, Z\}}{(1-\alpha)\beta} \cdot V_s^{\alpha/\beta} p^{-((1-\alpha)/\beta)}\right) & \text{if } \underline{p}_1 \leq p < V_s, \\[2ex] \dfrac{(1-\alpha)p - \alpha\min\{V, Z\}}{\beta p} & \text{if } V_s \leq p < \bar{p}_1, \end{cases} \tag{8}$$

where $\underline{p}_1 = V_s((\alpha(1-\alpha)\min\{V, Z\} - \alpha^2 V_s)/(\beta V_s))^{\beta/(1-\alpha)}$, $\bar{p}_1 = \min\{V, Z\}$, *and Z is the solution of*

$$\left(\frac{\beta V_s}{\alpha}\right)^{\alpha/(1-\alpha)} [(1-\alpha)Z - \alpha V_s]^{\beta/(1-\alpha)} = \alpha Z \ln\frac{V_s}{Z} + (2-3\alpha)Z - s\beta - \alpha V_s. \tag{9}$$

2. *If* $V < V_s$, *then* $F_1(p) = (1/(1-\alpha))[1-\alpha(V/p)^{(1-\alpha)/\beta}]$, $\bar{p}_1 = V$, *and* $\underline{p}_1 = \alpha^{\beta/(1-\alpha)}V$.
Total profits of each firm across the two periods are equal to $\underline{p}_1$.

Proof. For the complete proof, see Web Appendix A. □

As one can see from the above lemma, similar to the second-period pricing game, the equilibrium prices and consumer strategy are different depending on the value of V. The price distribution is bounded either by consumers' incentive to search when V is large or by consumer valuation for the products when V is small. In the former case, V becomes irrelevant in determining the equilibrium prices; in the latter case, the exact value of s is not important (as long as it is large enough).

Although the exact price distribution in the first period is complex, an immediate implication of the above lemma is that taking into account consumer loss aversion never completely eliminates the optimality of price promotions. It only indicates that their magnitude and distribution must be adjusted to account for their negative impact on future profits. We summarize this conceptual implication in the following proposition.

Proposition 2. *Consumer loss aversion and firms' forward-looking behavior in equilibrium never eliminate the optimality of price promotions even in the first period.*[19]

Proof. This immediately follows from Lemma 2's result that the first-period equilibrium price distribution is nondegenerate. □

The intuition for the above proposition is that no matter how strong the future negative effect of the current promotions may be, it is continuous in the promotion's depth and decreases to zero as the price reduction decreases to zero. On the other hand, if promotions were absent, the short-term benefit of a promotion coming from attracting consumers who observe both prices is positive and bounded away from zero no matter how small the promotion is.

Just as the result in Proposition 1, this result may be seen as driven by the assumption of lumpiness of demand (i.e., the presence of a mass of consumers with zero search costs) and therefore not surprising. However, it may be insightful because, more generally, it can be viewed as stating that when competition leads to price promotions in a static game, forward-looking effects—even when magnified by consumer loss aversion—do not change the nature of the game.

[19] This reflects a prisoner's dilemma situation: although each firm finds it optimal to use promotions, both firms could be better off if they did not use promotions. We thank an anonymous reviewer for this observation.

This proposition also underscores the dilemma faced by managers in a competitive environment. Specifically, one can assert that price promotions are a shortsighted competitive tool in the presence of loss aversion. At any given time, the manager may regret that she was unable to exercise more "disciplined pricing" in the past and now has to bear the consequence of consumers incentivized to search. It is tempting to view such an outcome as a dynamic inconsistency in the decision making of managers who are unable to restrain themselves or, alternatively, who are myopic or not given enough long-term incentives. In difference, the above proposition suggests that the persistence of promotions and the resulting downward trend in prices is consistent with the fully forward-looking and optimal behavior of individual firms in a competitive environment.

In what follows, we will see an even stronger result: in some cases, loss aversion may lead to optimality of stronger promotions in the first period. This result can be somewhat counterintuitive, and to see it, we need to more carefully consider the joint effect of loss aversion on the optimal range and the upper bound of the first-period price distribution.

4.4. Implications of Consumer Loss Aversion

Comparing the results in Lemmas 1 and 2 to the results of the benchmark model, we can see the effect of consumer loss aversion on firm pricing.

Proposition 3. *Consumer loss aversion increases expected first-period prices and profits but decreases expected second-period prices and profits.*

Proof. This follows from Lemmas 1 and 2 compared with the outcome of the benchmark model. □

As discussed above, the intuition for this result is that the forward-looking behavior of firms trying to ameliorate the negative effect of first-period promotions on the second-period profits softens the competition in the first period and results in higher prices. This effect has two components, a direct component and a strategic component. The direct component is that each firm has less incentive to cut its own price when consumers are loss averse since in the second period, lower reference price leads to lower profits. Therefore, firms should optimally promote less in the first period. Note that this component, as applied to own pricing, has a positive effect on that firm's price but a negative effect on its profit because it constrains prices to be higher than short-term optimal. However, this direct effect of loss aversion on one firm's price leads to other firm earning higher profits. Because firms in competition benefit from an overall rise in prices, this effect applied equally to both firms benefits each of them. The strategic component is that each firm is allowed to price higher and engage less in price competition because its competitor is now less concerned about cutting prices. Note that this strategic effect is especially strong if the first-period prices are not constrained by the consumer valuation. The two components together drive up the equilibrium prices and profits of firms in the first period when consumers are loss averse.

In the second period, because the equilibrium price distribution is always cropped by the reference price, the profits are capped by the profit in the benchmark model as well. So average prices and profits are always lower than those in the benchmark model. Whether overall profits across the two periods are higher or lower is not immediately clear. Comparing the equilibrium profits of firms in the two models, we have the following proposition.

Proposition 4. *When $V > V_s$, so that the equilibrium price is bounded by the consumer incentive to search in the model without consumer loss aversion, consumer loss aversion could lead to higher firm profits. On the other hand, when the equilibrium price is bounded by consumer valuation ($V < V_s$), consumer loss aversion always leads to lower firm profits.*

Proof. This follows from Lemmas 1 and 2 compared with the outcome of the benchmark model. □

To understand the intuition for the second result, note that in a mixed strategy equilibrium, firms are indifferent between different prices charged. Yet when the equilibrium price distribution is bounded by consumer valuation, the highest equilibrium price in the first period is the same in the model with and without consumer loss aversion. At this price, first-period profit remains the same as in the benchmark model (since at the highest price, only the consumers with positive search costs buy), yet the expected second-period profit is strictly lower when consumers are loss averse as a result of the probabilistic certainty that the other firm priced below the highest possible equilibrium price. So overall, firms cannot possibly enjoy higher overall profit (given any equilibrium price in the first period). When V is large such that equilibrium price is constrained by consumer search intention rather than consumer valuation, the upper bound of the equilibrium price distribution also shifts upward, which opens the possibility of higher firm profits. Therefore, only in this area can we (and, according to the above proposition, do we) sometimes observe higher expected total profits when consumers are loss averse.

To illustrate how the effect of loss aversion depends on the parameter values, first note that although our model has three parameters— α, V, and s—the results in Lemmas 1 and 2 and those of the benchmark model show that s could be normalized to 1, or equivalently, we only need to consider two parameters: α and V/s.

Figure 1 shows the percentage difference of total profits in the main model relative to the total profits in the benchmark model depending on V/s (top) and α (bottom). These plots illustrate the magnitude of the effect of loss aversion on profits. If the percentage change is positive, loss aversion increases firms' profits. If it is negative, it reduces firms' profits. Figure 2 illustrates the region of V/s and α under which profits increase.

Given the discussions above, the influence of V/s on the effect of loss aversion (top plot) is quite intuitive. If V/s is small enough, the equilibrium price distribution in the first period is bounded by the consumer valuation, and according to Proposition 4, firms cannot benefit from consumer loss aversion. When V/s is large enough, consumer loss aversion allows first-period prices to shift upward, and the total profits improve. As the top portion of Figure 1 illustrates, when $\alpha = 0.4$, total profits increase as a result of loss aversion when V/s is large enough. Note also that when V/s is large enough, the equilibrium price distribution does not depend on consumer valuation, so the line is flat for large enough V/s.

The influence of α on the relative profit change as a result of loss aversion (Figure 1, bottom plot) is less straightforward. To better understand this effect, let us consider on an intuitive level the trade-offs a firm faces when adjusting its pricing strategy from the equilibrium one in the benchmark model to account for the effect of loss aversion.

When considering pricing at the bottom of the price distribution, the firm realizes that the price it sets

Figure 1 Percentage Change in Equilibrium Profits Due to Consumer Loss Aversion as a Function of V/s for $\alpha = 0.4$ (Top) and as a Function of α for $V/s = 10$ (Bottom)

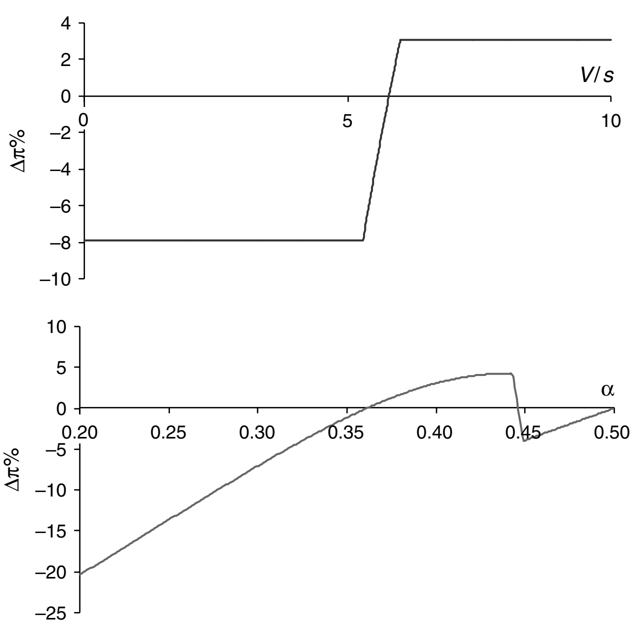
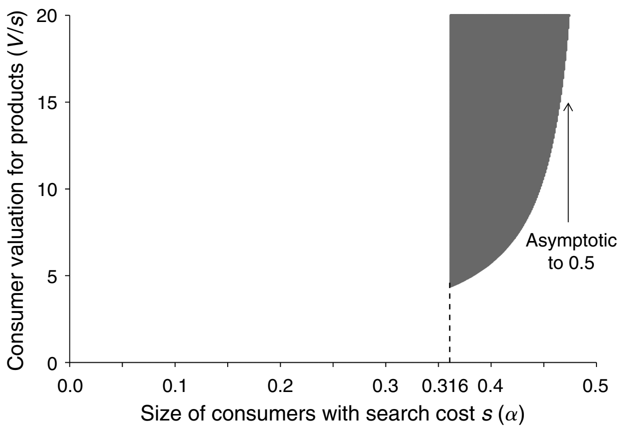


Figure 2 **Region Where Loss Aversion Increases Profits**



will likely become the consumer reference price in the second period and thus will adversely affect its second-period profit. This gives firms the incentive to avoid the lowest prices of the equilibrium price distribution of the benchmark case. The result is that the lowest price charged in equilibrium increases. At the top of the price distribution, the firm realizes that the competitor will almost certainly undercut its price, and therefore, its price will not affect the consumer reference price in the second period. The main consideration here is the level that is sufficient to prevent search by consumers with positive search costs. Given that the range of the price distribution was cut off from the bottom as discussed above, the highest price the firm can charge and still not induce consumer search increases (from that in the benchmark model) roughly by the same amount as the price distribution was cut off from the bottom. The result is that, roughly speaking, the equilibrium price distribution shifts up by a certain amount as determined by some probability of reaching the bottom portion of the benchmark price distribution.

The shift of the price distribution above V_s is the most beneficial to the firms because when prices are set above V_s in the first period, first-period profits increase and second-period profits are not affected by consumer reference price. Pricing below V_s still increases first-period profits but decreases second-period profits. Under what α does a shift up in the price distribution lead to a larger proportion of prices actually ending up above V_s? To answer this question, notice that as α increases, the price distribution reallocates to the top since chasing the smaller segment of consumers with zero search costs becomes less desirable. Therefore, a range of the bottom prices determined by a given probability is larger (relative to the whole range of the price distribution) when α is larger.[20] This leads to the first-period benefit of consumer loss aversion increases in α.

The above consideration applies as far as prices are not bounded by consumer valuation and corresponds to the leftmost upward slope of the bottom plot of Figure 1. However, as α increases, the top of the first-period price distribution increases as well and is certain to surpass V at some point. (See Equation (3) for the top price V_s in the benchmark case; the first-period price becomes bounded by consumer valuation at even lower values of α.) Once the valuation constraint becomes binding, the distribution of prices can no longer shift up as much. This corresponds to the first kink down in the plot. When even the benchmark model price distribution is bounded by consumer valuation, loss aversion is sure to have a negative effect. Yet at the same time, both prices in the main model and the benchmark model become constrained by consumer valuation. This corresponds to the kink up in the plot. As α increases to $\frac{1}{2}$, the price distribution compresses to a point, which means prices do not change and therefore consumers do not experience losses. This results in profits in the case of the main and benchmark models converging to the same value as $\alpha \to \frac{1}{2}$. We summarize this discussion in the following proposition.

Proposition 5. *The profit-increasing effect of consumer loss aversion is monotonic in V; i.e., either the profit is always lower than in the case of no loss aversion or it is higher when V is large enough. Yet the profit-increasing effect of consumer loss aversion is not monotonic in α.*

Proof. See Web Appendix A. □

The intuitive discussion above helps us understand the conditions under which consumer loss aversion may help competing firms. Competition must be strong enough so that the main constraint on prices is the threat of consumer search for a better price as opposed to consumers dropping out of the market. At the same time, competition should not be so strong as to result in price distribution that is too dispersed. Again, this is because the wider the price distribution, the more negatively loss aversion affects profits in the second period, and the lower the benefit from the price distribution shifting up in the first period.

We now return to the question of how loss aversion affects price dispersion, i.e., the range of the equilibrium price distribution.

Proposition 6. *Although consumer loss aversion always leads to the higher lower bound on the price distribution in the first period and a lower proportional range of equilibrium prices relative to the highest price charged, the absolute range of equilibrium prices in the first period may increase because of consumer loss aversion.*

Proof. It follows from comparison of Lemma 2 to the solution of the benchmark model. □

[20] Using the equations in Lemma 2 and the benchmark model, one can confirm that the top of the price distribution increases by a larger percentage of the range of the price distribution when α is larger.

The increase in the lowest price charged in equilibrium is quite intuitive, but the possibility of higher (absolute) price dispersion warrants further elaboration. The intuition is that because of the increase in the lowest prices possible in equilibrium, consumers have a lower incentive to search; this allows the firm to charge higher prices without inducing consumer search. The resulting distribution of prices is again such that at the highest price, consumers with positive search cost are indifferent between searching and not. In other words, the distance between the highest price charged and the average price remains the same. This implies that whether the range of prices increases depends on how consumer loss aversion affects the skewness of the equilibrium price distribution. We do not see an a priori reason for either direction, and the above proposition confirms that it can go either way.

5. Extensions, Robustness, and Further Discussion

To better understand the practical implications of the model analyzed in the previous sections, it is important to understand the role of the main conceptual assumptions we made and whether the results would remain the same or how they would change if we modify the way the conceptual assumptions are formulated in the model.

The discussions in the previous sections emphasized the importance of several features of the model—notably, the profit-increasing effect of loss aversion cannot exist without the long-term effect of reference prices, i.e., without past prices affecting current reference prices. As we consider different reference point formation mechanisms in §§5.3 and 5.4, we will see that the profit and pricing effects may be shown when the reference price is determined by the rational expectations of the price the consumer expects to pay (as in the framework of Kőszegi and Rabin 2006) but only if the past price provides information about the future price or when reference prices are formed at the time when past prices are relevant. We have also noted that it is essential that competition be sufficiently intense so that prices are constrained by search costs as opposed to consumer valuation, but not too intense so that the range of statically optimal distribution of prices is not too wide. While emphasizing the importance of the above market characteristics, we next argue that the specifics of reference-price formation and its assumed effect on search versus valuation is not crucial, and we discuss how the model could be extended to more than two periods.

5.1. Loss Aversion Affecting Consumer Valuation

In §3, we modeled loss aversion as directly affecting consumer search behavior. An alternative way to capture loss aversion is to assume that it affects consumer utility; e.g., assume that the consumer utility of buying from firm j is equal to

$$U_j = V - p_j - I\gamma(p_j - p^r), \tag{10}$$

where $\gamma > 0$ is the loss aversion parameter and I is the indicator of the domain of losses: $I = 1$ if $p_i > p^r$ and $I = 0$ otherwise (see, e.g., Ho et al. 2006). Such a formulation means that consumers experience a disutility proportional to the difference in price if and only if the observed price is higher than the reference price.

It is easy to see that with this formulation, when V is high enough the absolute value of consumer utility will not be a binding constraint in consumer purchase decisions either. However, the change in utility not only affects whether consumers would buy or not buy, but it also affects consumers' incentives to search. Specifically, if a consumer faces price $p_j > p^r$, the benefit of finding a lower price p_{3-j} is increased over that of the benchmark model by $\gamma(p_j - p_{3-j})$ if $p_{3-j} > p^r$ and by $\gamma(p^j - p^r)$ otherwise. In other words, when V is high enough, the effect of loss aversion modeled through reduced consumer utility (Equation (10)) is equivalent to a higher incentive to search when the price exceeds the reference price.

Thus, the loss-aversion-affecting-utility and the loss-aversion-affecting-search assumptions are closely related to each other—in both cases, when V is high enough, prices are driven down due to stronger consumer intention to search. The consumers' incentive to search derived from Equation (10) is not as strong as in the main model. Therefore, the equilibrium second-period prices are higher than those in the main model, and both the positive (first-period) and the negative (second-period) profit implications of consumer loss aversion are reduced but remain the same directionally. However, when γ tends to infinity the equilibrium second-period price distribution converges to the equilibrium price distribution of the main model since a price even slightly above the reference price induces search. Consequently, the first-period effect also converges to the first-period effect in the main model. Thus, the main results of the main model must hold when γ is large enough.[21] Thus, we obtain the following proposition.

Proposition 7. *The main model where loss aversion affects consumer search behavior is equivalent to the limiting case of the model in which loss aversion affects consumer utility of purchase.*

Firms' overall profit under the current framework can be either higher or lower than that in the effect-on-search framework. For example, it will be lower when

[21] These results do not require a large γ, but the argument above allows us to avoid a more complicated proof.

γ is small enough (and thus the model becomes close to the benchmark model) in those cases where loss aversion is found to increase firm profit in the main model; it will be higher when γ is small enough and V is bounded by consumer valuation.

5.2. Consistency of Reference Prices with Consumer Rationality

Whenever a psychological effect is introduced in a rational agent model, a natural question arises: Is it internally consistent to assume that agents are fully rational in all aspects except for the psychological effect assumed? One way to address this is to consider the possibility that some consumers are not fully rational and that they are the only ones affected by the reference price. In other words, the assumption is that fully rational consumers are not affected by reference prices; therefore any effects of reference prices are driven by consumers who are not rational. Because we cannot assume that rationality drives the behavior of such consumers, we must fully postulate their decision rules. For example, consider the not-fully-rational segment of consumers following a simple rule of buying the product if its price is below their valuation and their reference price, and not buying at all otherwise.

To explicitly formulate this variation of the main model, we assume that the following three consumer segments are present in each time period: (1) the perfectly rational (and not subject to loss aversion) mass-β segment of consumers with zero search cost, (2) the perfectly rational mass-2α segment of consumers with search cost $s > 0$, and (3) the segment of boundedly rational consumers of mass $2\gamma = 1 - 2\alpha - \beta > 0$. All consumers have valuation V. The boundedly rational consumers go to their favorite store (half to store 1 and the rest to store 2) and buy there if and only if they observe price below valuation (in the first period) or below valuation and their reference price (in the second period), where the reference price is the lowest realized first-period price in the two stores. To see the effect of loss aversion in this model, we compare it to the model where the boundedly rational consumers are unaffected by the reference price.

The analysis of the above model (see Web Appendix B) leads to results similar to those in the main model as long as γ and α are not too small and V is not too large. When γ is not too small, firms are unwilling to price this segment out of the market in the second period (by pricing above their reference price), and they are unwilling to lose the rational consumers with positive search cost by pricing at $V > V_s$ unless V is very large or α is small.

For example (see Web Appendix B for details), for $s = 1$, $\alpha = 0.15$, $\beta = 0.2$, $\gamma = 0.25$, and $V = 8.40$, the equilibrium total profit of each firm equals 4.2312 without loss aversion but 4.3605 with loss aversion.

5.3. Reference Price Determined by Price Expectations

Another possibility of adapting reference prices to rational expectations is the personal equilibrium framework of Kőszegi and Rabin (2006). In the most straightforward adaptation of this reference price definition to our main model, the model reduces to a twice-repeated static game since past prices are not predictive of future prices. This leads to loss aversion for prices having only a negative impact on the equilibrium price dispersion range and profits.[22] The intuition for this result is that loss aversion restricts pricing at high levels but does not affect pricing at lower levels given that consumers form their reference price without knowledge of the current price (for the necessity of the latter assumption, see Kőszegi and Rabin 2006). Because loss aversion does not prevent firms from lowering prices, consumer incentives to search when observing higher prices are not reduced either. Therefore, loss aversion may only have a negative effect; i.e., both the effect through valuation and the effect through the rational incentive to search are negative.

However, if past prices matter in the formation of consumer reference prices, the intuition behind the main forces in our model still holds. Below, we demonstrate how our main results could hold in a model where the reference price is formed through the above framework. For this, we extend the model to make current (first-period) price relevant for the reference price in both periods. As Heidhues and Kőszegi (2008) noted, it is quite realistic that past prices should enter the reference price formed through the personal equilibrium framework when the model is rich enough.

A model variation perhaps most consistent with the Heidhues and Kőszegi (2008) argument is that past prices could be predictive of future prices, at least for some consumers. For example, in the model extension in §5.2, one may consider the boundedly rational consumers to be unfamiliar with the nature of the game and therefore expect that the equilibrium is in pure strategies and that the prices reflect a certain margin on cost. They then expect the price in the next period to be exactly the same. On the other hand, the fully rational consumers know the structure of the game exactly. In this case, the previous section analyzed the model assuming the unlikely case of mixed strategy, whereas the pure strategy case would lead to no difference between consumers having and not having loss aversion. However, complete analysis of this game is complicated because of the possibility that the firm(s) may want to signal (through pricing) the structure of the game to consumers who do not

[22] This assumes that loss aversion for product value could have an opposite effect.

fully know the structure. For a formal analysis, we therefore adopt a slightly different approach to explain why past prices may matter. From a conceptual view, we consider the possibility that consumers do not know whether they can "catch the store open" in the first period. Formally, we consider the following extension of the main model.

As in the main model, consider two firms competing in two periods, with all consumers having the same valuation V and free observation of the first price. Yet assume that consumers are split into four types as follows: Type 1 consumers with mass 2α arrive at the beginning of the first period, have search cost s, and are not affected by reference prices. Type 2 consumers with mass m_2 arrive in the middle of the first period and can choose to buy the product in either period. However, if they buy in the second period, they will obtain a much lower utility (δV) since they forgo the first-period utility of using the product (we focus on the case when V is large enough such that all Type 2 consumers prefer to buy in the first period). Type 2 consumers, by virtue of arriving late in the first period, can observe both prices in the first period without incurring search costs, but they can only observe one price for free once they are in the second period. If they decide to buy in the first period (as in equilibrium, they will), there is an exogenous probability q that they will be unable to make the purchase in the first period (e.g., they could not leave work early enough to go to the store). Because consumers are rational, they are aware of this possibility; i.e., their strategy involves the contingency of what to do in the second period if the first-period purchase did not happen. Thus, their reference price is equal to the expected price paid, which takes into account the possibility that they are unable to buy in the first period. Type 3 consumers with mass m_3 arrive in the second period and have search cost 0. Type 4 consumers with mass m_4 have search cost s and arrive in the second period of the model. For simplicity, we assume that the numbers of consumers with search cost 0 and those with search cost s stay the same in both periods. This means $m_3 = (1-q)m_2$ and $2\alpha = qm_2 + m_4$, so that the total mass of consumers in both periods equals $2\alpha + (1-q)m_2$. Normalizing the total mass of consumers in each period to 1 leads to $(1-q)m_2 = 1-2\alpha$. Assume that only Type 2 consumers are loss averse. Note that when no consumers are loss averse, the model is exactly the same as the benchmark model of §4.

In accordance with the personal equilibrium framework of Kőszegi and Rabin (2006), Type 2 consumers' reference price is formed when they need to formulate their shopping/purchase strategy and derived from their expectation of the prices as well as their own behavior observing the prices, where the behavior is optimal given the reference price.[23] Specifically, before going to the store in the first period, they already know that with probability $(1-q)$ they will pay the lower price in the first period and with probability q they (as it turns out in equilibrium) will pay a random price in the second period. So their expected price paid, and therefore the reference price, will be the weighted average of first-period minimum price and second-period average price. In the second period, if they observe a price higher than the reference price, they will continue searching. This assumption is the same as that used in the main model. This is also consistent with Kőszegi and Rabin's (2006, 2009) framework, since the reference price is determined by the consumer's expectation, which will be fulfilled given the equilibrium strategies.

Solving this model (see Web Appendix B), we find that firms can still enjoy higher profits as a result of consumer loss aversion when V is large enough and that both α and q are in an intermediate range. The intuition for the effect of V and α is the same as in the main model. The intuition for the intermediate range of q is that when q is too small, a large proportion of consumers with positive search cost is not affected by loss aversion in the second period, and firms have the incentive to deviate to a higher price and just sell to consumers not affected by loss aversion. When q is very large, the reference price heavily depends on prices in the second period and is much lower than the minimum price in the first period. This results in a negative effect that is too strong in the second period. For example (see Web Appendix B), the total profit increases as a result of loss aversion when $\alpha = 0.42$, $q = 0.4$, $s = 1$, and V is large enough not to be a constraint on prices in equilibrium.

5.4. Other Reference-Price Formation Mechanisms

Although the assumptions in §2 are in a significantly reduced form, we believe they capture the essence of price loss aversion and are also simplified enough to make it easy to consider the model, analyze it, and understand the intuition behind it. However, the reality of reference-price formation and its effect on consumer behavior may differ in several respects from our model. In the previous subsection, we explored a notable modification of reference-price formation, which makes reference prices easier to endogenously define in a more general setting. In this section, we discuss a few

[23] As Kőszegi and Rabin (2006, 2009) noted, their model accommodates different assumptions on when reference prices are formed. Yet to have any effect, it has to occur somewhat before the purchase decision. We assume here that consumers form reference prices when they enter the market and before they make a costly decision. In other words, the reference price is formed after they observe first-period prices (which were set before these consumers entered the market) but before the second-period prices are set.

other reduced-form specifications of reference-price formation.

In the main model, we assumed that consumers know both of the past prices, and the reference price is determined by the lower price of the previous period. Alternatively, one may assume that consumers know only one of the prices, e.g., in a repeat purchase context, the price of the firm previously purchased from. Even if consumers know both past prices, the price they actually paid in the past may be the more relevant determinant of the reference price, or the reference price could be a (weighted) average of past prices.

The intuition behind the main results of the paper still holds under each of these alternative assumptions and hence the main results should not be affected. Specifically, two forces play a crucial role. One is that second-period profit should be positively related to first-period prices so that firms are less incentivized to engage in price competition in the first period. The other is that firms need to be forward-looking so that the dynamics of the model can come into play. These two forces together compel firms to increase price in the first period. Because the first force is an independent assumption, we only need to consider how the alternative reference-price formation mechanisms affect the first force.

If consumers' reference prices are only determined by the product they purchased in the previous period, reference prices are heterogeneous among consumers. In the second period, some consumers will have a higher reference price than others. For ease of discussion, denote the higher reference price by p_h^r and the lower one by p_l^r. Similar to the main model, if both p_h^r and p_l^r are higher than the equilibrium price range of the benchmark model, then the equilibrium of the benchmark model should still constitute an equilibrium in the current setting. If either p_h^r or p_l^r is below the upper bound of the equilibrium price of the benchmark model, then the price will be lowered because at least some of the consumers will now search and buy from the other firm when the price is above their reference point. So price competition will be intensified between the two firms. This intuition is the same as the main model. In the main model, because of consumers' incentive to search, the price in the second period is bounded by the reference price p^r. In the current case, the equilibrium price distribution could potentially be bounded by p_h^r or p_l^r. If the gap between p_h^r and p_l^r is small, then price should be bounded by p_l^r, and the equilibrium is the same as the main model. If the gap between p_h^r and p_l^r is large, then firms will have incentive to abandon customers with a lower reference price by raising the price to p_h^r. On the equilibrium path, consumers with search cost s are expected to divide equally between the two firms. So in the second period, if p_h^r is less than $2p_l^r$, the equilibrium should remain the same as the main model, and the solution to the whole model will also remain unchanged. In fact, this could happen in the equilibrium. For example, when $\alpha = 0.4$ and V/s are sufficiently large, the upper and lower bounds of the equilibrium price distribution in the first period of the main model are equal to 6 and 4.36, respectively. This means $p_h^r < 2p_l^r$ will always be satisfied in the equilibrium. Also notice that under these parameters, firms will benefit from loss aversion in the main model, and consequently, they will also benefit under this alternative assumption. So the main result of the paper is robust to this change.

Let us now consider the possibility that the reference price in the second period depends on both prices in the previous period but is the same across consumers. The subgame equilibrium results derived for the second period of the main model still apply here because they only depend on the value of p^r, not on how it is formed. So in the second period, the equilibrium price and profit still decline with the reference price p^r. Since p^r is equal to a weighted average of first period prices, it decreases if either one of the prices decreases. This means the first-period price still positively correlates to second-period profit, and this gives firms incentive to raise prices in the first period. Because the second-period reference price is not as low as in the main model, we expect the profit-lowering effect in the second period and the profit-enhancing effect in the first period to be weaker. However, qualitatively, all effects remain the same as in the main model, and the main results of the paper should be robust to this change. As an example, consider the special case where consumers' reference price in the second period is determined by the higher price in the first period. When price is bounded by consumers' incentive to search in the benchmark model, the upper bound of equilibrium price is equal to V_s. When loss aversion is present, this upper bound will be higher than V_s. When firms charge the upper bound price, the resulting reference price will always be larger than V_s, leading to the same equilibrium price and profit in the second period compared to the benchmark model. However, in the first period, expected profit will be higher than the benchmark model. So overall, firms will always benefit from loss aversion as long as price is bounded by consumer search in the benchmark model. Compared with the main model where the profit-increasing effect of loss aversion is only observed for some parameter values, this alternative assumption increases the area where it can happen. This shows the robustness of the results to this change of assumption.

It is possible that the dynamic effect could be present, yet forward-looking firms would not take it into account. For example, suppose the reference price equals the past price paid and consumers exhibit a strong variety-seeking tendency so that the probability of purchase from the same firm is negligible. If firms could target these consumers, then the resulting decrease in competitor's price might not negatively affect firms' pricing and profits in the second period. This could lead to an increase in the competitive level as a result of variety seeking (Zeithammer and Thomadsen 2013 showed such a possibility in a much more direct way).

5.5. Competition Over More Than Two Periods

In §3, we model the effect of consumer loss aversion in a two-period game. Although we believe such a formulation is sufficient to reveal the dynamic effect of loss aversion, it may be interesting to discuss what additional insights could be obtained if we model the effect of loss aversion over more time periods. Consider a variation of the model in §3 with more than two time periods, and in each period other than the first one, consumers are affected by a reference price equal to a weighted average of past prices. Other assumptions are the same as in the main model.

The last period of this game is the same as in the main model. So last-period profit is always lower than in the absence of consumer loss aversion. In each period in between, firms maximize their expected profit from that period on. In addition to the incentives in the static model, firms are affected by two dynamic effects stemming from consumer loss aversion. On the one hand, the reference price formed from past prices influences consumer search behavior in the current period and escalates competition between firms. This effect will drive down the average price in the market compared with the model without consumer loss aversion. On the other hand, firms are concerned about the impact of their current pricing decision on future profits. Because lowering price results in lower reference price and lower future profits, firms are less incentivized to engage in price competition. This effect will drive up the average price in the market. Whether the combined force of the two effects will result in higher or lower prices in the market should depend on the value of the reference price. If the reference price is high, then the former effect should be very weak relative to the latter, and we should expect the average price to be higher than that in the benchmark model. If the reference price is low, however, the first effect will be very strong, and the average price is likely to be lower than that in the benchmark model. In the first period, firms are only affected by the concern of the effect of current pricing on future profits. Price will certainly be higher than the benchmark model. Except for the last period, profit in each period should be higher than the benchmark model with some probability. So in the multiperiod model, firms could still be better off with consumer loss aversion if the potential increase in profit in earlier periods can compensate for the decrease in profit in the last period.

One of the implications of the main model is that prices will keep declining over time on the equilibrium path. In a multiperiod model, we will still arrive at this result if it is assumed that the reference price is equal to the lower price charged by the two firms in the previous period. Although firms have the incentive to raise price due to concern for future prices, equilibrium price will still be bounded by the reference price. Deviation by either firm to a higher price results in zero profit in the current period and the same profit in the future. Thus neither firm will deviate. Because the reference price is determined by the lower price in the previous period, the observed prices will decline on the equilibrium path. Note that since the incentive to promote comes from capturing the segment of consumers with positive mass while the long-term effect is continuous in the price change, no matter how important the long-term effect is, the range of prices can dwindle to zero only if the highest price charged declines to zero. Therefore, over time, prices will approach marginal costs. In other words, the implications of this version of the multiperiod game are similar to those in the durable goods monopoly game, even though we have repeated demand.

One of the assumptions we have made for simplicity is that products are undifferentiated. Let us consider a slightly modified version of the model. In the modified model, we assume that there is a fraction ϵ (where ϵ is arbitrarily small) of consumers loyal to each of the firms, or alternatively, a small fraction of consumers have high search costs (even after the loss aversion effect is taken into consideration). Among the rest of consumers, $(1-\epsilon)\beta$ have zero search cost and $(1-\epsilon)(1-\beta)=(1-\epsilon)2\alpha$ have search cost s. The loyal consumers only buy from their preferred firm and are not affected by loss aversion. The rest of the model is the same as the foregoing model. In this model, although prices are at high enough levels, firms would optimally price so as to not induce the larger segment of consumers with positive search costs to search. Because the number of loyal consumers is small by assumption, they do not affect the optimal pricing strategy of firms. So conditional on prices not being too low, equilibrium prices will be the same as the model without the loyal consumers. However, when prices decline to a sufficiently low level, it becomes optimal to "give up" on consumers who exhibit the loss aversion effect and set prices high to sell only to this small fraction of loyal consumers. At some point, both firms will set prices at this high level, and therefore the reference price will reset to this high level.[24] With

[24] This high level is not exactly V, since for the possibility that both firms set the high price, it is optimal to price slightly below V. Thus the price distribution at the top is also mixed.

the reference price now at a high level, optimal pricing will resume on the downward trend. This result is formally summarized in the following proposition.

Proposition 8. *In the multiperiod model with an arbitrarily small segment of loyal consumers, equilibrium prices will exhibit a cyclical pattern; i.e., they repeatedly decline over time for some periods before being reset to a higher level.*

Proof. See Web Appendix B. □

5.6. Consumer Value of Gains

What will happen if consumers respond to both gains and losses? If the consumer response to gains is captured by a consumer's reluctance to search after observing a price lower than their reference price, results of either the benchmark model or the main model would not change, and hence all the results in §4.4 carry over. The reason is as follows: Consumers with search cost zero are essentially not affected by loss aversion since they always optimally search for both prices. In the equilibrium, firms always price in such a way that consumers with a positive search cost do not find it optimal to continue searching at the highest equilibrium price. But at the highest price, the gain effect does not exist.

However, the effect of gains on the utility is often captured by an extra gain from finding a lower price. In other words, the presence of *either* the effect of losses or the effect of gains corresponds to a higher incentive to search relative to a model without reference point dependence. As a result, second-period prices and profits will be dragged down even more than when consumers are only sensitive to losses. The effect in the first period may be a stronger incentive for firms to raise prices.

It is also possible that reference prices affect consumers' expected utility through the price-quality inference. In this case, higher prices may result in consumers' updating their product valuation upward. This in turn could lead to even higher prices becoming feasible in future periods, and it raises the possibility of a "virtual cycle" (from the firms' point of view) of increasing prices and quality perceptions. Such effects of references prices on product value warrant further research.

6. Conclusion

One of the observed regularities of consumer behavior is that consumer preferences are reference dependent. In particular, in a pricing context, consumers may be affected by reference prices in their purchase decisions and may be more sensitive to losses than to gains. In this paper, we investigated the implications of this consumer loss aversion for the optimal pricing strategy and profitability of firms in a competitive environment.

Although our model captures important aspects of the marketplace—competition, promotions, consumer lack of information and search costs, long- and short-term firm considerations, and the tension between immediate and future profits—we abstracted away from nonpricing decisions. As expected, we found that second-period profit is reduced as a result of the effect of loss aversion and that forward-looking behavior of firms leads to lower attractiveness of price promotions in the first period. Furthermore, less use of promotions by one firm allows the other firm to engage less in price competition and charge a higher price. These two forces reinforce each other in driving up the equilibrium price in the first period and lead to the somewhat counterintuitive result that overall profits may increase in the presence of consumer loss aversion. Moreover, we identified conditions for this result. First, consumer valuation for the products must be high enough relative to consumer search costs so that the equilibrium price distribution is bounded by consumers' search incentive as opposed to their valuation. Second, the fraction of consumers with higher search cost must be in an intermediate range.

Although the presence of consumer loss aversion discourages firms from using price promotion in the first period, it never completely eliminates the optimality of promotions. Firms should still find it optimal to use price promotion as a competitive tool, but they may want to promote less. This finding underscores an important dilemma faced by competing firms—although price promotion leads to lower profit, firms cannot and should not get away from it. The model also captures the notion that price promotions are "addictive" in the sense that once firms start to give discounts, they have to discount even more deeply in the next period to attract consumers. Although the above results are not unexpected by practitioners, a somewhat more nuanced result is that when the regular price (i.e., the upper limit of the price distribution) is set as optimal given consumer behavior, the optimal maximal depth of price promotions (even in the first period) could be higher in the presence of consumer loss aversion.

We also extended the analysis of the model to consider other reasonable assumptions that may realistically capture market characteristics and consumer behavior. We discussed the intuition and results of the model when loss aversion affects consumer valuation with more time periods and under alternative formation processes of reference prices, and we showed that the main results of the paper are fairly robust to these extensions. One implication of the main model adapted to multiple periods is that prices will keep declining over time as a result of the effect of loss aversion. We show that if we slightly modify the model by adding an arbitrary small fraction of loyal consumers, then the prices of the products will exhibit a cyclical pattern, which perhaps better corresponds to the observed regularities of the contemporary marketplace.

Supplemental Material

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References

Bell D, Bucklin R (1999) The role of internal reference price in the category purchase decision. *J. Consumer Res.* 26(2):128–143.

Bell DR, Lattin JM (2000) Looking for loss aversion in scanner panel data: Confounding effect of price-response heterogeneity. *Marketing Sci.* 19(2):185–200.

Benartzi S, Thaler RH (1995) Myopic loss aversion and the equity premium puzzle. *Quart. J. Econom.* 110(1):73–92.

Biswas A, Blair EA (1991) Contextual effects of reference price in retail advertisements. *J. Marketing* 55(July):1–12.

Bolton L, Warlop L, Alba J (2003) Consumer perceptions of price (un)fairness. *J. Consumer Res.* 29(4):474–491.

Briesch R, Krishnamurthi L, Mazumdar T, Raj SP (1997) A comparative analysis of reference price models. *J. Consumer Res.* 24(2):202–214.

Cui TH, Raju JS, Zhang ZJ (2007) Fairness and channel coordination. *Management Sci.* 53(8):1303–1314.

Farber HS (2008) Reference-dependent preferences and labor supply: The case of New York City taxi drivers. *Amer. Econom. Rev.* 98(3):1069–1082.

Feinberg FM, Krishna A, Zhang ZJ (2002) Do we care what others get? A behaviorist approach to targeted promotions. *J. Marketing Res.* 39(3):277–291.

Galanter E, Pliner P (1974) Cross-modality matching of money against other continua. Moskowitz HR, Scharf B, Stevens JC, eds. *Sensation and Measurement* (Reidel, Dordrecht, The Netherlands), 65–76.

Greenleaf E (1995) The impact of reference price effects on the profitability of price promotions. *Marketing Sci.* 14(1):82–104.

Grewal D, Monroe K, Krishnan R (1998) The effects of price-comparison advertising on buyers' perceptions of acquisition value, transaction value, and behavioral intentions. *J. Marketing* 62(2):46–59.

Gul F (1991) A theory of disappointment aversion. *Econometrica* 59(3):667–686.

Hardie BGS, Johnson EJ, Fader PS (1993) Modeling loss aversion and reference dependence effects on brand choice. *Marketing Sci.* 12(4):378–394.

Heidhues P, Kőszegi B (2008) Competition and price variation when consumers are loss averse. *Amer. Econom. Rev.* 98(4):1245–1268.

Ho TH, Zhang J (2008) Designing pricing contracts for boundedly rational consumers: Does the framing of the fixed fee matter? *Management Sci.* 54(4):686–700.

Ho TH, Lim N, Camerer CF (2006) Modeling the psychology of consumer and firm behavior with behavioral economics. *J. Marketing Res.* 43(4):307–331.

Ho TH, Lim N, Cui TH (2010) Reference dependence in multilocation newsvendor models: A structural analysis. *Management Sci.* 56(11):1891–1910.

Hong H, Shum M (2006) Using price distributions to estimate search costs. *RAND J. Econom.* 37(2):257–275.

Honka E (2010) Quantifying search and switching costs in the U.S. auto insurance industry. Working paper, University of Texas at Dallas, Dallas.

Jeuland A, Narasimhan C (1985) Dealing-temporary price cuts-by seller as a buyer discrimination mechanism. *J. Bus.* 58(3):295–308.

Kahneman D, Tversky A (1979) Prospect theory: An analysis of decision under risk. *Econometrica* 47(2):263–292.

Kalwani M, Yim C (1992) Consumer price and promotion expectations: An experimental study. *J. Marketing Res.* 29(February):90–100.

Kalyanaram G, Winer RS (1995) Empirical generalization from reference price research. *Marketing Sci.* 14(3, Supplement): G161–G169.

Kopalle PK, Rao AG, Assunção JL (1996) Asymmetric reference price effects and dynamic pricing policies. *Marketing Sci.* 15(1):60–85.

Kőszegi B, Rabin M (2006) A model of reference-dependent preferences. *Quart. J. Econom.* 121(4):1133–1165.

Kőszegi B, Rabin M (2009) Reference-dependent consumption plans. *Amer. Econom. Rev.* 99(3):909–936.

Krishnamurthi L, Mazumdar T, Raj SP (1992) Asymmetric response to price in consumer brand choice and purchase quantity decisions. *J. Consumer Res.* 19(3):387–400.

Lal R (1990) Price promotions: Limiting competitive encroachment. *Marketing Sci.* 9(3):247–262.

Lal R, Little JDC, Villas-Boas JM (1996) A theory of forward-buying, merchandising, and trade deals. *Marketing Sci.* 15(1):21–37.

Lattin J, Bucklin R (1989) Reference effects of price and promotion on brand choice behavior. *J. Marketing Res.* 26(3):299–310.

Lynch JG Jr, Ariely D (2000) Wine online: Search costs affect competition on price, quality, and distribution. *Marketing Sci.* 19(1):83–103.

Markowitz H (1952) The utility of wealth. *J. Political Econom.* 60(2): 151–158.

Mazumdar T, Raj SP, Sinha I (2005) Reference price research: Review and propositions. *J. Marketing* 69(4):84–102.

Moraga-Gonzalez J, Wildenbeest M (2008) Maximum likelihood estimation of search costs. *Eur. Econom. Rev.* 52(5):820–848.

Narasimhan C (1988) Competitive promotional strategies. *J. Bus.* 61(4):427–449.

Narasimhan C, Turut Ö (2013) Differentiate or imitate? The role of context-dependent preferences. *Marketing Sci.* 32(3):393–410.

Narasimhan C, He C, Anderson E, Brenner L, Desai P, Kuksov D, Messinger P, et al. (2005) Incorporating behavioral anomalies in strategic models. *Marketing Lett.* 16(3):361–373.

Orhun AY (2009) Optimal product line design when consumers exhibit choice set-dependent preferences. *Marketing Sci.* 28(5):868–886.

Putler DS (1992) Incorporating reference price effects into a theory of consumer choice. *Marketing Sci.* 11(3):287–309.

Rajendran KN, Tellis G (1994) Contextual and temporal components of reference price. *J. Marketing* 58(1):22–34.

Rao RC (1991) Pricing and promotions in asymmetric duopolies. *Marketing Sci.* 10(2):131–144.

Smith G, Venkatraman M, Dholakia R (1999) Diagnosing the search cost effect: Waiting time and the moderating impact of prior category knowledge. *J. Econom. Psych.* 20(3):285–314.

Stahl D (1989) Oligopolistic pricing with sequential consumer search. *Amer. Econom. Rev.* 79(4):700–712.

Streitfeld D (2000) Amazon flunks its pricing test/sliding costs anger shoppers. *San Francisco Chronicle* (September 28), B-4.

Thaler R (1985) Mental accounting and consumer choice. *Marketing Sci.* 4(3):199–214.

Varian H (1980) A model of sales. *Amer. Econom. Rev.* 70(4):651–659.

Winer R (1986) A reference price model of brand choice for frequently purchased products. *J. Consumer Res.* 13(2): 250–256.

Wingfield N, Stelter B (2011) How Netflix lost 800,000 members, and good will. *New York Times* (October 24), http://www.nytimes.com/2011/10/25/technology/netflix-lost-800000-members-with-price-rise-and-split-plan.html.

Zeithammer R, Thomadsen R (2013) Vertical differentiation with variety-seeking consumers. *Management Sci.* 59(2):390–401.

Zhou J (2011) Reference dependence and market competition. *J. Econom. Management Strategy* 20(4):1073–1097.