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# Market Dominance and Behavior-Based Pricing under Horizontal and Vertical Differentiation

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# Market Dominance and Behavior-Based Pricing under Horizontal and Vertical Differentiation\*

## Abstract

We evaluate behavior-based price discrimination from an antitrust perspective by focusing on an industry with inherited market dominance. Under horizontal differentiation, behavior-based pricing does not by itself lead to persistence of dominance unless the dominant firm is protected by significantly higher switching costs than its small rival. This result continues to hold even if the dominant firm can use behavior-based pricing to compete against an entrant with no access to consumers' purchase histories. Under vertical differentiation, behavior-based pricing enhances the dominance of the high-quality seller, but it also promotes consumer welfare.

**JEL Classification:** D4, L1, L41.

**Keywords:** Market Dominance, Behavior-Based Pricing, Consumer Loyalty, Poaching, Price Discrimination, Horizontal and Vertical Differentiation.

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# 1. Introduction

In today's business environment firms have access to technologies which enable them to price discriminate according to revealed purchase histories. Such behavior-based price discrimination raises important and topical antitrust issues. Clearly, in a simple monopoly market structure, price discrimination serves as an instrument whereby the monopolist can increase the surplus extracted from consumers in order to enhance its profits. As shown initially by Thisse and Vives (1988), the consequences of price discrimination under oligopoly differ dramatically from those under monopoly. They demonstrated that when firms compete strategically with completely individualized prices (perfect price discrimination) competition is intensified relative to the outcome of competition with uniform prices.

In this paper we focus on behavior-based price discrimination and ask how the strategic use of pricing schemes targeted to loyal customers affects industry performance. In particular we ask the following question: Does the business practice of behavior-based price discrimination serve as a strategic device to enhance market dominance? Can behavior-based price discrimination serve as an instrument for a dominant firm to induce exclusion of a smaller competitor? What is precisely the relationship between behavior-based prices and uniform prices, and how does an inherited market share asymmetry affect this relationship? Can an incumbent firm make strategic use of behavior-based price discrimination as a mechanism to deter entry? These crucial issues are highly significant when, for example, evaluating the business practice of targeted price schemes to loyal customers within the framework of Article 82 in the European Union. In such a context the question is whether a price scheme targeted to loyal consumers qualifies as an abuse of a dominant market position. Some studies, for example Geroski (1987), have tried to empirically evaluate how effective market processes are in eliminating market dominance.

In industries in which consumers bear switching costs from changing brands firms have strategic incentives to establish business relationships with customers. The business

relationships are profitable because firms can exploit locked-in customers up to a limit determined by the switching costs. In an equilibrium with behavior-based price discrimination firms attract their rivals' customers with competitive poaching offers. Thus, within such a framework, the prices charged to loyal customers exceed the poaching offers. However, the prices charged to both customer categories are below the equilibrium prices with uniform price schemes. Fudenberg and Tirole (2000) was a seminal contribution for a general analysis of behavior-based pricing whereas Chen (1997), Taylor (2003) and Gehrig and Stenbacka (2004, 2007) present applications of more specialized symmetric duopoly models of this type.<sup>1</sup> Chen (forthcoming) analyzes a dynamic asymmetric duopoly model and finds that behavior-based price discrimination tends to benefit consumers as long as it does not induce exit of the weaker firm. Furthermore, even in the absence of switching, firms can learn about customer preferences with repeated shopping. Behavior-based price discrimination allows firms to offer lower prices in the form of poaching prices to buyers that have revealed a relatively low preference, while loyal customers reveal a relatively strong preference. As long as customers have persistent preferences firms can make use of behavior-based price discrimination to exploit the loyal customers by imposing a loyalty premium such that the prices charged to loyal customers exceed the poaching offers.

Contrary to the literature cited above, this paper explores how well behavior-based pricing serves as an instrument for maintaining or even enhancing a firm's inherited market dominance. Unlike, for example Fudenberg and Tirole (2000), we assume that market dominance is exogenously inherited and assume that established customer relationships can be exploited up to a limit determined by the switching costs. With competition based on behavior-based pricing in a horizontally differentiated industry we find that dominance does not persist for a duopoly firm with inherited dominance unless this firm is protected by a sufficiently strong switching cost advantage. In particular, in the absence of switching costs a small rival firm has strong incentives to engage in poaching in such a way that the dominant firm is bound to lose its dominance even when it competes with behavior-

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<sup>1</sup>Fudenberg and Villas-Boas (2006) present an updated survey on the literature focusing on behavior-based price discrimination.

based discriminatory schemes. Furthermore, the equilibrium market share of the firm with inherited market dominance is always smaller under competition with behavior-based pricing than under competition with uniform pricing. If the dominant firm has inherited a monopoly position and if it is faced with an entry threat by a horizontally differentiated firm, which a priori has an equally strong brand appeal to newly-entering consumers, it can make use of behavior-based pricing to maintain its dominance as long as it is protected by some switching cost. However, if the newly-entering consumers are oriented towards the entrant, dominance persists only if protected by sufficiently high switching costs.

Further, we distinguish the equilibrium configuration with behavior-based pricing in a horizontally differentiated industry from that in a vertically differentiated industry. We show that the lock-in effects of established customer relationships are quality-contingent with behavior-based pricing, and that a high-quality firm with inherited dominance will be able to strengthen its dominance as long as the inherited dominance is not too strong. This captures the idea that in equilibrium more customers belonging to the inherited market share of the low-quality firm switch to the high-quality firm than in the opposite direction. Finally, in a vertically differentiated industry in which firms apply behavior-based strategies we establish the following remarkable property: A stronger market dominance of the high-quality firms enhances aggregate consumer welfare. Thus, under vertical product differentiation consumers benefit from strengthened market dominance induced by behavior-based pricing.

Armstrong and Vickers (1993), Bouckaert, Degryse and van Dijk (2007) and Chen (forthcoming) have studied some welfare effects of policies which ban dominant firms from using price discrimination. These studies focus on price discrimination within a framework where the dominant firm operates in an exogenously determined sheltered segment as well as a segment subject to competition. Contrary to these approaches, we explore the consequences of behavior-based price discrimination within a framework where the loyal segment of the dominant firm is endogenously determined. Further, and contrary to these studies, we explore the consequences of behavior-based pricing by a dominant firm

both as an instrument when competing with an existing small rival and as an instrument for entry deterrence with newly-entering consumer populations with different types of brand preferences. Finally, we distinguish the consequences of behavior-based pricing in horizontally differentiated industries from those of vertically differentiated industries.

Our study is divided into two parts: Section 2 investigates whether behavior-based pricing can be used to enhance market dominance in a market for horizontally differentiated brands. Section 3 conducts similar investigations under vertical product differentiation. The relationship between behavior-based pricing and persistence of dominance under horizontal brand differentiation is investigated in several ways. Sections 2.1 and 2.2 serve as benchmarks by assuming that all firms inherit some loyal consumers from previous sales. Section 2.4 investigates how behavior-based pricing is used when competing with an entrant. Both, Sections 2 and 3 compare market dominance associated with behavior-based pricing to market dominance under uniform pricing and also explore some welfare implications.

## 2. Behavior-based Pricing under Horizontal Product Differentiation

Firms  $A$  and  $B$  produce differentiated brands. Firm  $A$  ( $B$ ) is located on the left (right) side of the unit interval. All costs of production are normalized to equal zero.

Consumers are uniformly distributed on the the unit interval according to increased preference for brand  $B$  (decreased preference for  $A$ ). Each consumer  $x$ ,  $x \in [0, 1]$  is endowed with a purchase history known to the firms. There are two periods labeled  $t = 0$  and  $t = 1$ . Let the function  $h(x) : [0, 1] \rightarrow \{A, B\}$  describe the purchase history of each consumer  $x$ . Thus,  $h(x) = A$  ( $h(x) = B$ ) implies that the consumer indexed by  $x$  has purchased brand  $A$  ( $B$ ) in period  $t = 0$ . Each consumer buys one unit from one of the firms.

Let  $p_A$  denote the price firm  $A$  sets for consumers who have already purchased brand  $A$

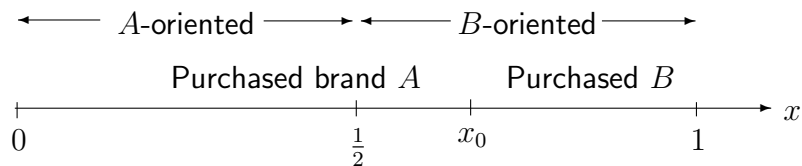
before, and  $q_A$  the price for those consumers who earlier purchased brand  $B$  (the competing brand). Firm  $B$ 's prices,  $p_B$  and  $q_B$ , are defined analogously. We interpret  $p_A$  and  $p_B$  as the prices for *loyal* consumers, whereas  $q_A$  and  $q_B$  are *poaching* prices.

Consumers bear exogenous switching costs. Let  $\sigma_{AB}$  ( $\sigma_{BA}$ ) denote the cost of switching from brand  $A$  to brand  $B$  (from  $B$  to  $A$ ). The utility of a consumer indexed by  $x$  with a purchase history of brand  $h(x) \in \{A, B\}$  is defined by

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \beta - p_A - \tau x & \text{if } h(x) = A \text{ and continues to purchase brand } A \\ \beta - q_B - \tau(1-x) - \sigma_{AB} & \text{if } h(x) = A \text{ and now switches to brand } B \\ \beta - p_B - \tau(1-x) & \text{if } h(x) = B \text{ and continues to purchase brand } B \\ \beta - q_A - \tau x - \sigma_{BA} & \text{if } h(x) = B \text{ and now switches to brand } A. \end{cases} \quad (1)$$

The first and third rows in (1) define the utility gained by customers who are loyal to  $A$  and  $B$ , respectively. The second and fourth rows define the utility gained by switching consumers. The parameter  $\beta$  measures the consumer's basic satisfaction. The parameter  $\tau \geq 0$  is the "transportation cost" parameter. A low value of  $\tau$  will be interpreted as intense brand competition. The brand switching cost parameters  $\sigma_{AB}$  and  $\sigma_{BA}$  can be interpreted to capture, for example, network externalities, compatibility, or learning costs.

Let  $x_0$  be given. We focus on a purchase history such that all consumers indexed by  $x \leq x_0$  ( $x > x_0$ ) belong to  $A$ 's ( $B$ 's) inherited market share. With no loss of generality we assume that  $x_0 > 0.5$  which captures that firm  $A$  is dominant. Figure 1 illustrates how the history of purchases relates to current brand preferences.



**Figure 1:** Characterization of purchase history.

In order to induce some consumers to switch brands we make the following assumption.

ASSUMPTION 1. *The average switching cost is lower than the transportation cost parameter. Formally,  $(\sigma_{AB} + \sigma_{BA})/2 < \tau$ .*

We classify purchase history as follows.

DEFINITION 1. *The purchase history  $x_0$  exhibits **weak dominance** if*

$$\max \left\{ \frac{\sigma_{AB} + \tau}{4\tau}, \frac{1}{2} \right\} \leq x_0 \leq \frac{3\tau - \sigma_{BA}}{4\tau}, \text{ and } \mathbf{strong\ dominance} \text{ if } x_0 > \frac{3\tau - \sigma_{BA}}{4\tau}.$$

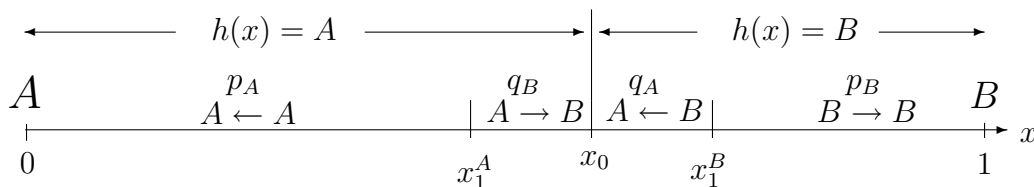
Note that by Assumption 1 the range for weak dominance is nonempty.

## 2.1 Weak dominance under horizontal differentiation

In view of the utility function (1), the consumer who has purchased  $A$  before and is now indifferent between being loyal to brand  $A$  and switching to brand  $B$ , denoted by  $x_1^A$ , is implicitly determined from  $\beta - p_A - \tau x_1^A = \beta - q_B - \tau(1 - x_1^A) - \sigma_{AB}$ . Similarly, the consumer who has purchased  $B$  before and is now indifferent between being loyal to brand  $B$  and switching to brand  $A$ , denoted by  $x_1^B$ , is implicitly determined from  $\beta - p_B - \tau(1 - x_1^B) = \beta - q_A - \tau x_1^B - \sigma_{BA}$ . Therefore,

$$x_1^A = \frac{1}{2} + \frac{q_B - p_A + \sigma_{AB}}{2\tau} \quad \text{and} \quad x_1^B = \frac{1}{2} + \frac{p_B - q_A - \sigma_{BA}}{2\tau}. \quad (2)$$

Equation (2) defines a new allocation of consumers between the brands as illustrated in Figure 2 below. The left segment in Figure 2 illustrates consumers who are loyal to



**Figure 2:** Consumer allocation between horizontally-differentiated brands under weakly asymmetric purchase history. *Note:* Arrows indicate consumers' choice in each segment.

brand  $A$ . These consumers pay a price of  $p_A$ . The second segment from the left is the

range of consumers who previously purchased  $A$  and have been poached by firm  $B$  for a price  $q_B$ . The third range of consumers are those who switch from  $B$  to  $A$  and thus pay the price  $q_A$ . The fourth range of consumers are those who are loyal to brand  $B$  and pay a price of  $p_B$ .

In view of Figure 2, the profit functions of firms  $A$  and  $B$  are defined by

$$\begin{aligned}\pi_A(p_A, q_A) &\stackrel{\text{def}}{=} p_A x_1^A + q_A (x_1^B - x_0) \\ \pi_B(p_B, q_B) &\stackrel{\text{def}}{=} p_B (1 - x_1^B) + q_B (x_0 - x_1^A).\end{aligned}\quad (3)$$

We now solve for the Nash equilibrium prices where firm  $A$  chooses  $p_A$  and  $q_A$  to maximize  $\pi_A$  and firm  $B$  chooses  $p_B$  and  $q_B$  to maximize  $\pi_B$ . Substituting the market shares (2) into the profit functions (3) obtains the Nash equilibrium loyalty prices

$$p_A = \frac{\tau(2x_0 + 1) + \sigma_{AB}}{3} \quad \text{and} \quad p_B = \frac{\tau(3 - 2x_0) + \sigma_{BA}}{3}, \quad (4)$$

and poaching prices

$$q_A = \frac{\tau(3 - 4x_0) - \sigma_{BA}}{3} \quad \text{and} \quad q_B = \frac{\tau(4x_0 - 1) - \sigma_{AB}}{3}. \quad (5)$$

Observe from (4) that switching costs raise loyalty prices because firms can exploit the lock-in effect generated by established business relationships. In contrast, (5) shows that switching costs result in lower poaching prices because firms have to partially subsidize the costs in order to induce switching.

Substituting the equilibrium prices (4) and (5) into (2) yields

$$x_1^A = \frac{2x_0 + 1}{6} + \frac{\sigma_{AB}}{6\tau}, \quad \text{and} \quad x_1^B = \frac{2x_0 + 3}{6} - \frac{\sigma_{BA}}{6\tau}. \quad (6)$$

We now compute the equilibrium market shares of firms  $A$  and  $B$ . From (6), in view of Figure 2, the market share of the dominant firm is

$$m_1^A = x_1^A + (x_1^B - x_0) = \frac{2 - x_0}{3} + \frac{\sigma_{AB} - \sigma_{BA}}{6\tau}. \quad (7)$$

Consequently, the market share of the dominant firm is decreasing in its inherited market share, thereby generating an effect of dominance reversal. However, this effect could be offset by a large switching cost advantage. The market share of the small firm is

$$m_1^B = 1 - x_1^B + x_0 - x_1^A = \frac{1 + x_0}{3} - \frac{\sigma_{AB} - \sigma_{BA}}{6\tau}. \quad (8)$$

Comparing (7) with (8) yields

**Result 1.** Let  $\Delta\sigma \stackrel{\text{def}}{=} \sigma_{AB} - \sigma_{BA}$ . With behavior-based price discrimination,

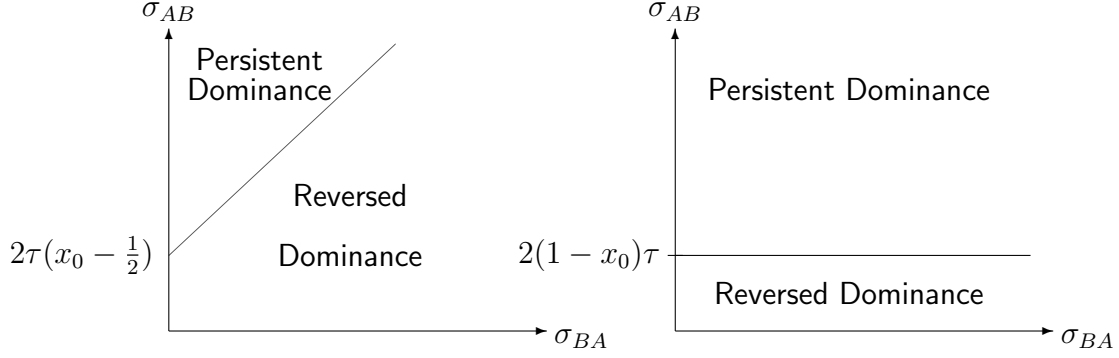
- (a) Market dominance persists ( $m_1^A = 1 - m_1^B > \frac{1}{2}$ ) if  $\Delta\sigma > 2\tau(x_0 - \frac{1}{2})$ .
- (b) Market dominance is reversed ( $m_1^A = 1 - m_1^B \leq \frac{1}{2}$ ) if  $\Delta\sigma \leq 2\tau(x_0 - \frac{1}{2})$ .

In our model the competing firms are equally efficient, which means that effective competition would break dominance in the absence of any discriminatory practice or switching costs. The persistence of dominance is determined through a tradeoff between two forces: asymmetric transportation costs and switching costs. Result 1(a) essentially captures the idea that dominance persists if the dominant firm is protected by a switching cost advantage, which exceeds the additional transportation costs associated with the asymmetric market shares. It should be emphasized that what matters here is the relative switching costs. In the special case where  $\sigma_{AB} = \sigma_{BA}$  market dominance is always reversed.

Intuitively, with inherited asymmetric market shares the small firm prices more aggressively. The dominant firm cannot defend its dominance unless it is protected by a sufficiently strong switching cost advantage. In this respect, behavior-based price discrimination does not by itself lead to exclusion of a smaller rival unless it is combined with another sufficiently strong strategic advantage like higher switching costs.

Figure 3(left) illustrates the difference in brand-specific switching costs required for persistence of market dominance.

Figure 4 illustrates the difference in switching costs required for persistence of market dominance as a function of the inherited market share dominance. In line with Result 1(a),



**Figure 3:** The effect of brand specific switching costs on persistence of dominance. *Left:* Weak dominance. *Right:* Strong dominance.

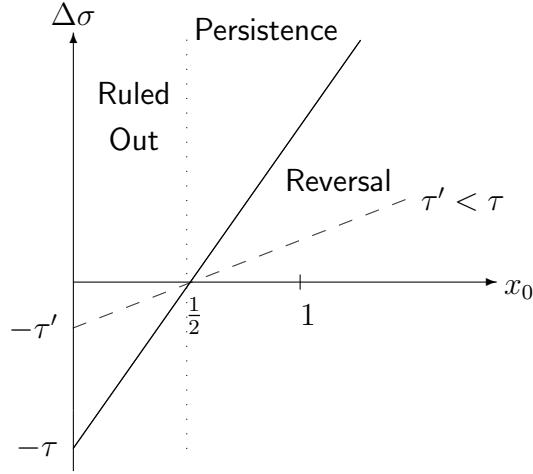
Figure 4 illustrates that a *lower*  $\tau$  expands the segment of persistent dominance. In fact, it follows directly from (4) and (5) that

$$\frac{\partial(p_A - q_A)}{\partial\tau} = \frac{2\tau(3x_0 - 1)}{3} > 0, \quad \text{and} \quad \frac{\partial(p_B - q_B)}{\partial\tau} = \frac{2(2 - 3x_0)}{3} < 0 \quad \text{if and only if} \quad x_0 < \frac{2}{3}. \quad (9)$$

That is, a decline in  $\tau$  induces the dominant firm to reduce the difference between loyalty and poaching prices. This result also holds for the prices set by the small firm as long as the inherited dominance is limited ( $x_0 < 2/3$ ). Intuitively, with intensified competition (lower  $\tau$ ) poaching is a stronger instrument to conquer market shares at the expense of the rival and for this reason the firms benefit from using more aggressive poaching. With intensified competition the dominant firm has to adjust its loyalty price to meet the competition from more aggressive poaching by lowering the loyalty price to a sufficient extent.

## 2.2 Strong dominance under horizontal differentiation

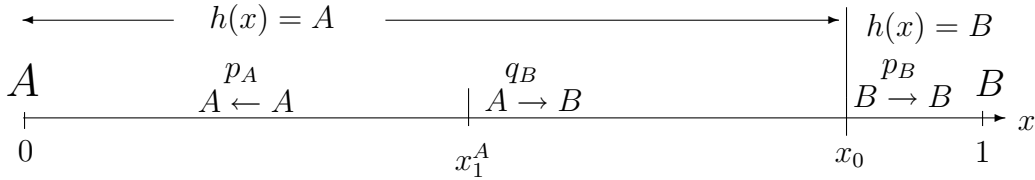
Suppose now that  $3/4 - \sigma_{BA}/(4\tau) < x_0 < 1$ , which by Definition 1 means strong dominance. This would eliminate the range of consumers indexed on the interval  $[x_0, x_1^B]$  in Figure 2. Therefore, in equilibrium the dominant firm  $A$  is unable to induce switching



**Figure 4:** Persistence versus reversal of market dominance. *Note:* A clockwise rotation reflects a decrease in  $\tau$ .

because its poaching activities would have to win consumers located much closer to firm  $B$ .

Figure 5 illustrates this configuration.



**Figure 5:** Consumer allocation between horizontally-differentiated brands under strongly asymmetric purchase history.

To compute the equilibrium prices supporting the configuration illustrated in Figure 5, we set firm  $A$ 's poaching price to equal marginal cost,  $q_A = 0$ . Comparing Figure 5 with Figure 2 reveals that now  $x_1^B = x_0$ . Substituting  $q_A = 0$  and  $x_1^B = x_0$  into (2), firm  $B$ 's best reply is to set a loyalty price of  $p_B = \tau(2x_0 - 1) + \sigma_{BA}$ . Since consumers are segmented by their purchase histories, the prices  $p_A$  and  $q_B$  remain unchanged. Altogether,

$$p_A = \frac{\tau(2x_0 + 1) + \sigma_{AB}}{3}, \quad q_A = 0, \quad p_B = \tau(2x_0 - 1) + \sigma_{BA}, \quad \text{and} \\ q_B = \frac{\tau(4x_0 - 1) - \sigma_{AB}}{3}. \quad (10)$$

The resulting market shares are

$$m_1^A = x_1^A = \frac{(2x_0 + 1)\tau + \sigma_{AB}}{6\tau} \quad \text{and} \quad m_1^B = 1 - m_1^A = \frac{(5 - 2x_0)\tau - \sigma_{AB}}{6\tau}. \quad (11)$$

Therefore,

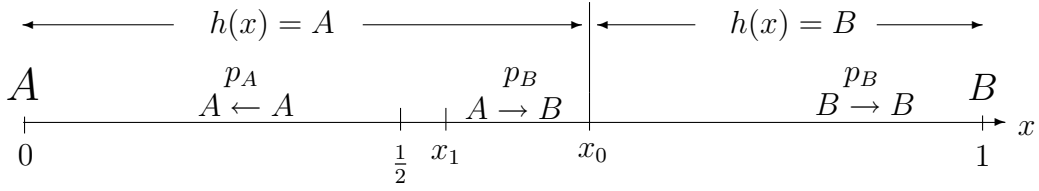
**Result 2.** *The firm with inherited strong dominance is bound to lose its dominance ( $m_1^A \leq \frac{1}{2}$ ) if and only if  $\sigma_{AB} \leq 2(1 - x_0)\tau$ .*

Clearly, under strong dominance the ability of firm A to maintain dominance is determined by the switching cost from A to B, whereas the switching cost from B to A is irrelevant. This feature distinguishes the configuration of inherited strong dominance from that of inherited weak dominance, where dominance persistence is determined by the difference in switching costs. Result 2 is illustrated on the right part of Figure 3. Finally, observe that similar to Figure 4, an increase in the intensity of competition (a lower  $\tau$ ) expands the parameter range where dominance persists.

### 2.3 Uniform pricing under horizontal differentiation

To be able to assess the implications of behavior-based pricing on competition in general, and under persistence of dominance in particular, this section briefly formulates and solves for price competition under uniform pricing. Then, the equilibrium prices and the corresponding market shares under uniform pricing are compared with those under behavior-based pricing already developed in Section 2.1 (weak dominance).

Figure 6 below illustrates the market shares when firms compete in uniform prices. Comparing Figure 6 with Figure 2 reveals that in the absence of price discrimination consumer switching may occur in one direction only. More precisely, the dominated firm, firm B, may win some consumers from the dominant firm, but not the other way around. We now solve for this equilibrium.



**Figure 6:** Consumer allocation between horizontally-differentiated brands under uniform pricing.

In view of Figure 6, with only two prices,  $p_A$  and  $p_B$ , faced by all consumers, the utility of a consumer indexed by  $x$  is now given by

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \beta - p_A - \tau x & \text{if } h(x) = A \text{ and continues to buy brand } A \\ \beta - p_B - \tau(1 - x) - \sigma_{AB} & \text{if } h(x) = A \text{ and now switches to brand } B \\ \beta - p_B - \tau(1 - x) & \text{if } h(x) = B \text{ and continues to buy brand } B. \end{cases} \quad (12)$$

Notice that  $\sigma_{BA}$  does not appear in (12) because there are no consumers who switch from  $B$  to  $A$  in an equilibrium with uniform pricing.

Under uniform pricing, a consumer  $x_1$  who is indifferent between being loyal to brand  $A$  and switching to brand  $B$  is determined by  $\beta - p_A - \tau x = \beta - p_B - \tau(1 - x) - \sigma_{AB}$ . Firm  $A$  chooses a single price  $p_A$  to maximize  $\pi_A = p_A x_1$ . Similarly, firm  $B$  chooses a single price  $p_B$  to maximize  $\pi_B = p_B(1 - x_1)$ . The unique Nash-Bertrand equilibrium in prices and firm  $A$ 's market share are given by

$$p_A^u = \tau + \frac{\sigma_{AB}}{3}, \quad p_B^u = \tau - \frac{\sigma_{AB}}{3}, \quad \text{and} \quad x_1^u = \frac{1}{2} + \frac{\sigma_{AB}}{6\tau} > \frac{1}{2}, \quad (13)$$

where superscript “ $u$ ” indicates uniform pricing. From (13) we can directly observe that with uniform prices the inherited dominance has no effect whatsoever on the price equilibrium and on the ability of the dominant firm to maintain its dominance. Of course, in the presence of switching costs firm  $B$  must undercut  $A$ 's price with a margin proportional to the switching costs in order to gain market share from  $A$ . Furthermore, in equilibrium dominance persists as long as there is some (even arbitrarily small) switching cost. We summarize this conclusion in

**Result 3.** *Under uniform pricing, market dominance persists as long as the dominant firm*

is protected by some switching cost. Furthermore, the surviving degree of dominance is monotonically increasing with this switching cost.

Notice that firm  $A$  continues to maintain its dominance even if it is protected by infinitesimally small switching costs (low but nonzero  $\sigma_{AB}$ ). In contrast, Result 1 demonstrates that the switching cost advantage must be sufficiently large in order for firm  $A$  to maintain its dominance under behavior-based pricing. In other words, under low switching cost advantage, dominance can persist only under uniform pricing whereas under behavior-based pricing dominance is reversed. In this respect, we can say that behavior-based pricing tends to promote competition more efficiently than uniform pricing.

This paper focuses on how different pricing methods affect the persistence of dominance. To investigate this, comparing firm  $A$ 's market share under uniform pricing (13) with  $A$ 's market share under behavior-based pricing (7) yields

$$x_1^u \geq m_1^A \quad \text{if} \quad \frac{1}{2} + \frac{\sigma_{AB}}{6\tau} \geq \frac{2 - x_0}{3} + \frac{\sigma_{AB} - \sigma_{BA}}{6\tau}, \quad (14)$$

which always holds because  $\sigma_{BA} \geq 0 > (1 - 2x_0)\tau$ . This implies the following result.

**Result 4.** *The equilibrium market share of the firm with inherited market dominance is always larger under uniform pricing than under behavior-based pricing.*

Another dimension of evaluation is to compare the equilibrium prices under uniform and behavior-based price discrimination. Comparing (13) with (4) and (5) yields the following result.

**Result 5.** *The equilibrium prices for all types of consumers are lower with behavior-based than with uniform prices when  $2\tau x_0 < \sigma_{AB} + \sigma_{BA} < 2\tau$ . This holds true also when  $\sigma_{AB} + \sigma_{BA} < 2\tau x_0$  with the exception that the small firm's loyalty price might then be higher than the uniform price charged by the small firm.*

Clearly, when  $2\tau x_0 < \sigma_{AB} + \sigma_{BA} < 2\tau$  behavior-based pricing benefits all consumers. Behavior-based pricing may also raise aggregate consumer welfare when  $\sigma_{AB} + \sigma_{BA} < 2\tau x_0$

even though consumers who are loyal to  $B$  are worse off. We refrain from providing the general formulation of aggregate consumer welfare, because the computations are rather tedious in the presence of switching costs.

## 2.4 Entry and behavior-based pricing

Our results have so far indicated that behavior-based pricing by itself can not lead to persistent market dominance. That is, the previous analysis showed that market dominance can persist only if the dominant firm is protected by high switching costs which consumers must bear if they wish to switch to another brand.

In this section we investigate whether an incumbent firm can use behavior-based pricing to maintain its dominance against an entering firm which does not have any inherited consumer base. In a sense entry can be considered as the case with zero inherited market share of the entrant. Thus, the entering firm cannot exercise behavior-based pricing, because it does not have access to any records of sales and consumers' purchase histories. Our goal in this section is to investigate whether the incumbent firm can maintain its dominance by utilizing its one-sided access to behavior-based strategies, which are not available to an entering firm. That is, whereas firm  $A$  can set the price  $p_A$  to its loyal consumers and  $q_A$  to new consumers, the entering firm  $B$  is confined to choosing a uniform price  $p_B = q_B$  applied to all consumers because the entrant cannot distinguish among consumers with different histories.

In this section we explore how asymmetric access to behavior-based pricing by the dominant firm affects the persistence of dominance. We assume the entry of new firm as well as the arrival of a new generation of consumers in period 2. In the first variant we focus on the situation where the new consumers are uniformly distributed on the unit interval so that the incumbent has no particular advantage or disadvantage with respect to the new customers. Subsequently we explore the consequences of the preference bias according to which all the new consumers have a preference orientation towards the entrant,  $B$ .

### 2.4.1 Entry into $A$ 's and $B$ 's markets

Consider a market in which the incumbent firm  $A$  inherits full market coverage, so  $x_0 = 1$ . Suppose now that a fraction  $\theta$  of the consumers are replaced by a new cohort, which is again uniformly distributed on  $[0, 1]$ . The new cohort has a choice of purchasing from the incumbent firm, or from the entrant, firm  $B$ . Firm  $A$ 's old customers can continue to be "loyal" to  $A$  or they can switch to the entering firm  $B$ , in which case they bear a switching cost of  $\sigma_{AB} \geq 0$ .

Firm  $A$  sets a price  $p_A$  to its loyal customers, and  $q_A$  to new consumers.<sup>2</sup> Firm  $B$  cannot distinguish among consumers, so it sets a single price  $p_B$  to all consumers (new consumers and consumers who switch from  $A$ ). Let  $x_1^n$  denote a new consumer who is indifferent between purchasing  $A$  and  $B$ . This consumer is determined from  $\beta - q_A - \tau x_1^n = \beta - p_B - \tau(1 - x_1^n)$ . Let  $x_1$  continue to denote an old consumer who is indifferent between being loyal to  $A$  and switching to the new brand  $B$ . This consumer is determined from  $\beta - p_A - \tau x_1 = \beta - p_B - \tau(1 - x_1)$ . Therefore,

$$x_1^n = \frac{1}{2} + \frac{p_B - q_A}{2\tau} \quad \text{and} \quad x_1 = \frac{1}{2} + \frac{\sigma_{AB} + p_B - p_A}{2\tau}. \quad (15)$$

Firm  $A$  chooses prices  $p_A$  and  $q_A$  to maximize  $\pi_A = q_A \theta x_1^n + p_A(1 - \theta)x_1$ . Firm  $B$  chooses a single price  $p_B$  to maximize  $\pi_B = p_B[\theta(1 - x_1^n) + (1 - \theta)(1 - x_1)]$ . The uniquely-determined equilibrium prices are

$$p_A = \tau + \frac{(2 + \theta)\sigma_{AB}}{6}, \quad q_A = \tau - \frac{(1 - \theta)\sigma_{AB}}{6}, \quad \text{and} \quad p_B = \tau - \frac{(1 - \theta)\sigma_{AB}}{3}. \quad (16)$$

Notice that  $p_A > q_A > p_B$  meaning that the entrant adopts a very aggressive pricing strategy by setting its single price even below the poaching price set by the incumbent. Substituting the equilibrium prices (16) into (15) obtains the incumbent's equilibrium market share among all consumers. Thus,

$$m_1^A = \theta x_1^n + (1 - \theta)x_1 = \frac{1}{2} + \frac{(1 - \theta)\sigma_{AB}}{6\tau} \geq \frac{1}{2}. \quad (17)$$

<sup>2</sup>Strictly speaking  $q_A$  is not a poaching price in this setting. Now  $q_A$  is the price charged by  $A$  to new customers, who have not inherited a business relationship with  $A$  from the previous period.

Therefore,

**Result 6.** *When the newly-entering consumers have preferences which are uniformly distributed between the incumbent and the entrant, the incumbent can maintain dominance as long as it is protected by some (arbitrarily small) switching cost.*

By comparing Result 1 and Result 6 we can draw the following conclusion. The ability of the firm with inherited dominance to maintain its dominance based on behavior-based pricing is stronger when it faces competition from an entrant with access to only a uniform price than when it faces an established small firm with access to behavior-based pricing. In the presence of competition from the entrant dominance is preserved as long as there are some switching costs. Furthermore, as (17) shows, the equilibrium market share of the incumbent is monotonically increasing with the switching costs as well as the proportion of consumers who have survived from the previous period.

It is instructive to compare the above results with the case in which the incumbent firm  $A$  is unable to price discriminate between loyal and new consumers. Formally, redoing the above computations assuming that firm  $A$  is restricted to setting a uniform price yields

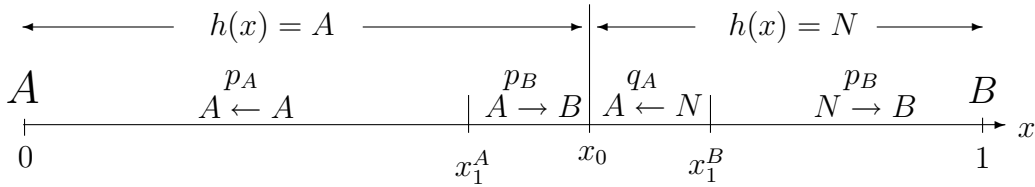
$$p_A^u = q_A^u = \frac{3\tau + (1 - \theta)\sigma_{AB}}{3}, \quad p_B^u = \frac{3\tau - (1 - \theta)\sigma_{AB}}{3}, \quad x_1^u = \frac{3\tau + (2\theta + 1)\sigma_{AB}}{6\tau},$$

$$x_n^u = \frac{3\tau - 2\sigma_{AB}(1 - \theta)}{6\tau}, \quad \text{and} \quad m_A^u = \theta x_n^u + (1 - \theta)x_1^u = \frac{3\tau + (1 - \theta)\sigma_{AB}}{6\tau} > \frac{1}{2},$$
(18)

where superscript “ $u$ ” denotes uniform pricing. Comparing (18) with (16) reveals that  $p_A > p_A^u$ ,  $q_A < p_A^u$ , and  $p_B = p_B^u$ , implying that consumers loyal to the incumbent firm are better off under uniform pricing, whereas new consumers buying from the incumbent are better off with behavior-based pricing. Finally, comparing (18) with (17) reveals that  $m_1^A = m_A^u$ , implying that the incumbent maintains the same degree of market dominance. Looking at market share considerations, the market discipline imposed by the entrant’s uniform price is equally efficient as the discipline imposed by a small firm able to engage in behavior-based pricing.

## 2.4.2 Entry into $B$ 's market

We continue to focus on two types of consumers. Part of the consumers are present in the market in period 1, and all of them buy from the only available firm,  $A$ , in period 1. In contrast, entering new customers in period 2 inherit no business relationship, and we formally denote this by the history  $h(x) = N$ .  $h(x) = A$  continues to represent a consumer who has purchased brand  $A$  before. We assume that entering consumers are oriented towards  $B$ . Figure 7 illustrates a purchase history where all consumers indexed on  $[0, x_0]$  have purchased from  $A$ , but all other consumers are new. Figure 7 is very



**Figure 7:** Consumer allocation between the brands after firm  $B$  enters.

similar to Figure 2, except that (a) Firm  $B$  is restricted to setting a single price  $p_B$  for all consumers, and (b) initially there are no consumers who have purchased from firm  $B$ . Figure 7 is drawn based on a modification of consumers' utility function (1) which is now given by

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \beta - p_A - \tau x & \text{if } h(x) = A \text{ and continues to purchase brand } A \\ \beta - q_A - \tau x & \text{if } h(x) = N \text{ and now buys brand } A \\ \beta - p_B - \tau(1 - x) - \sigma_{AB} & \text{if } h(x) = A \text{ and now switches to brand } B \\ \beta - p_B - \tau(1 - x) & \text{if } h(x) = N \text{ and buys the new brand } B. \end{cases} \quad (19)$$

Notice that (19) implies that all consumers who buy  $B$  pay the same price,  $p_B$ , regardless of whether they switch from  $A$ , or whether they are new consumers. This is because firm  $B$  is new and is therefore unable to use past sales records for discriminating in price between new and switching consumers. In fact one way to motivate this model of entry is that the underlying preference space is growing over time thereby inducing entry of a new firm.

The utility function (19) implies that the equations  $\beta - p_A - \tau x_1^A = \beta - p_B - \tau(1 - x_1^A) - \sigma_{AB}$  and  $\beta - p_B - \tau(1 - x_1^B) = \beta - q_A - \tau x_1^B$  determine the indifferent consumers  $x_1^A$  and  $x_1^B$  who also define the cutoff market segments between firms  $A$  and  $B$ . Therefore, similar to (3), firm  $A$  now chooses  $p_A$  and  $q_A$  to maximize  $\pi_A = p_A x_1^A + q_A(x_1^B - x_0)$ . Firm  $B$  chooses a single price  $p_B$  to maximize  $\pi_B = p_B(1 - x_1^B + x_0 - x_1^A)$ .

The equilibrium prices are  $p_A = (2x_0\tau + 5\sigma_{AB} + 8\tau)/12$ ,  $q_A = (8\tau - \sigma_{AB} - 10x_0\tau)/12$ , and  $p_B = (2x_0\tau - \sigma_{AB} + 2\tau)/6$ . The market segments are therefore defined by  $x_1^A = (2x_0\tau + 5\sigma_{AB} + 8\tau)/(24\tau)$  and  $x_1^B = (14x_0\tau - \sigma_{AB} + 8\tau)/(24\tau)$ . Consequently, the incumbent firm's market share is

$$m_1^A = x_1^A + (x_1^B - x_0) = \frac{4\tau + \sigma_{AB} - 2x_0\tau}{6\tau} \geq \frac{1}{2} \quad \text{if and only if} \quad \sigma_{AB} \geq \tau(2x_0 - 1). \quad (20)$$

We can therefore state the following result.

**Result 7.** *When the newly-entering consumers are oriented towards the entrant, the incumbent firm maintains its dominance only if it is protected by sufficiently high switching costs as characterized by (20). Otherwise the incumbent firm loses its dominance.*

By comparing Result 1 and Result 7 we can draw the following conclusion. The ability of the firm with inherited dominance to maintain its dominance is invariant to whether it faces competition from an established small firm with access to behavior-based pricing or an entrant with access to only a uniform price. It should be emphasized that this conclusion holds true when the newly-entering consumers are endowed with preferences oriented towards the entrant. Under these circumstances the uniform price is already a very strong instrument for the entrant. Moreover, comparing (20) with (7) and (8) in the absence of switching costs ( $\sigma_{AB} = 0$ ) reveals that the small firm gains the same market share regardless of whether the small firm is an entrant with no purchase history, or an established firm.

From comparing Result 7 with Result 6 we can conclude that the ability of the incumbent firm to maintain dominance through the use of behavior-base pricing in the presence

of entry is highly dependent on characteristic of newly-entering consumers with no purchase history. In line with intuition, the incumbent's ability to maintain dominance is much stronger when the new consumers are uniformly distributed on the unit interval compared with the situation where these have a preference orientation towards the entrant.

### 3. Behavior-based Pricing under Vertical Product Differentiation

Our results so far have shown that, in the absence of switching costs, behavior-based pricing cannot enhance market dominance. Section 2.4 has also demonstrated that this result continues to hold even when the dominant firm has exclusive access to behavior-based pricing, while the entrant is restricted to uniform pricing. However, all these investigations were conducted under the assumption that the brands are *horizontally* differentiated. A natural question to ask at this stage is whether the same result continues to hold in an industry in which the brands are *vertically* differentiated.

#### 3.1 Benchmark model

Consider an industry with two firms producing brand  $A$  and brand  $B$ . The brands are called *vertically differentiated* if, at equal prices  $p_A = p_B$ , all consumers prefer brand  $B$  over brand  $A$ . Such an industry is captured by the utility function

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \alpha x - p_A & \text{if buys brand } A \\ \beta x - p_B & \text{if buys brand } B, \end{cases} \quad \text{where } \beta > \alpha > 0, \quad (21)$$

for every consumer  $x \in [0, 1]$ . Thus, the utility function assumes that firm  $B$  produces the high-quality brand.

In the absence of behavior-based pricing, firm  $A$  chooses a single price  $p_A$  to maximize  $\pi_A = p_A \hat{x}$  and firm  $B$  chooses  $p_B$  to maximize  $\pi_B = p_B(1 - \hat{x})$ , where  $\hat{x}(p_A, p_B)$  is determined by  $\alpha \hat{x} - p_A = \beta \hat{x} - p_B$ . The equilibrium prices and  $A$ 's market share are given

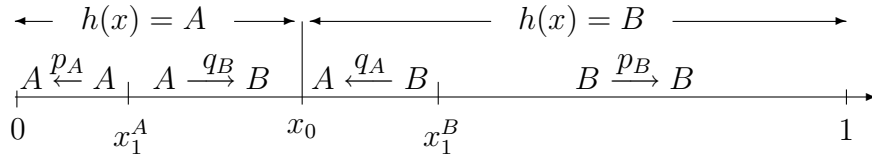
by

$$p_A = \frac{\beta - \alpha}{3}, \quad p_B = \frac{2(\beta - \alpha)}{3}, \quad \text{and} \quad \hat{x} = \frac{1}{3}. \quad (22)$$

Therefore, in the absence of behavior-based pricing the high-quality firm, firm  $B$ , captures  $2/3$  of the market, charges twice the price as firm  $A$ , and therefore makes a higher profit.

### 3.2 Behavior-based pricing under vertical differentiation

We now investigate the persistence of the high-quality firm's ( $B$ 's) market dominance if both firms have access to the option of behavior-based pricing. Figure 8 exhibits possible inherited market shares and the new market shares which build as a result of the use of behavior-based pricing by both firms. Figure 8 reflects a situation where the high-



**Figure 8:** Consumer allocation between vertically-differentiated brands.

quality firm  $B$  inherits a larger market share than the low-quality firm  $A$  (the opposite of the assumed dominance under horizontal differentiation). These inherited shares may, for example, be the equilibrium outcome of an earlier price game with no behavior-based pricing, which we have shown to yield  $x_0 = 1/3$ .

In view of Figure 8 and given the purchase history parameter  $x_0$ , in the absence of switching costs the utility functions (23) are now given by

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \alpha x - p_A & \text{if } h(x) = A \text{ and continues to purchase brand } A \\ \beta x - q_B & \text{if } h(x) = A \text{ and switches to brand } B \\ \beta x - p_B & \text{if } h(x) = B \text{ and continues to purchase brand } B \\ \alpha x - q_A & \text{if } h(x) = B \text{ and now switches to brand } A, \end{cases} \quad (23)$$

where, as before,  $\beta > \alpha > 0$  indicate that brand  $B$  is the high-quality brand. In view of Figure 8, (23) implies that  $x_1^A$  is determined from  $\alpha x_1^A - p_A = \beta x_1^A - q_B$ , and  $x_1^B$  from  $\alpha x_1^B - q_A = \beta x_1^B - p_B$ . Therefore,  $x_1^A = (q_B - p_B)/(\beta - \alpha)$  and  $x_1^B = (p_B - q_A)/(\beta - \alpha)$ .

The solutions to the firms' profit maximization problems (3) yield the loyalty prices

$$p_A = \frac{(\beta - \alpha)x_0}{3} \quad \text{and} \quad p_B = \frac{(\beta - \alpha)(2 - x_0)}{3}, \quad (24)$$

and the equilibrium poaching prices

$$q_A = \frac{(\beta - \alpha)(1 - 2x_0)}{3} \quad \text{and} \quad q_B = \frac{(\beta - \alpha)2x_0}{3}. \quad (25)$$

The “dividing” consumers and the equilibrium market shares are then given by

$$x_1^A = \frac{x_0}{3}, \quad x_1^B = \frac{x_0 + 1}{3}, \quad m_1^A = \frac{1 - x_0}{3}, \quad \text{and} \quad m_1^B = \frac{x_0 + 2}{3}, \quad (26)$$

where  $m_1^A = x_1^A + (x_1^B - x_0)$  and  $m_1^B = (1 - x_1^B) + (x_0 - x_1^A)$ . This leads to the following result.

**Result 8.** (a)  $m_1^B > 1 - x_0$  if  $x_0 > \frac{1}{4}$  (weak dominance). That is, behavior-based pricing increases the market share of the high-quality producer.

(b)  $m_1^B < 1 - x_0$  if  $x_0 < \frac{1}{4}$  (strong dominance). That is, behavior-based pricing decreases the market share of the high-quality producer.

Result 8(a) states that the high-quality firm  $B$  can increase its market share by implementing behavior-based pricing techniques. Formally, this result holds regardless of whether the high-quality firm starts from a dominant position or from a weak position. In particular, if this firm inherits a dominant position, behavior-based pricing further enhances its position. Result 8(b) shows that if the high quality-firm inherits an extremely large market share (strong dominance), then it will lose some of its dominance even when the firm implements behavior-based pricing. Lastly, if  $x_0 = \frac{1}{4}$  then  $m_1^B = 1 - x_0$  which means that behavior-based pricing leaves market shares at the same levels as the inherited market shares.

Suppose, in particular, that the inherited history is determined by an initial phase, where the vertically differentiated firms compete with uniform prices. As we have demonstrated above, competition in the vertically integrated industry would generate market

dominance for the high-quality firm, more precisely a market share  $2/3$ . Thus, Result 8(a) would apply perfectly well to an inherited history generated through such a plausible mechanism. In particular, substituting  $x_0 = 1/3$  into (26) yields  $m_1^A = 2/9 < 1/3$  and  $m_1^B = 7/9 > 2/3$ , which means that the dominant firm enhances its market share by  $1/9$  with the use of behavior-based pricing. Note that this was not possible under horizontal product differentiation.

Result 8(a) captures the idea that under weak dominance the lock-in effects of established customer relationships are quality-contingent with behavior-based pricing. Thus, in equilibrium the high-quality firm has more loyal customers than the low-quality firm. Consequently, in equilibrium more customers belonging to the inherited market segment of the low-quality firm switch to the high-quality firm than in the opposite direction.

### 3.3 Welfare analysis under vertical differentiation

Section 3.2 has established under weak dominance that behavior-based pricing will strengthen an inherited market dominance of the high-quality firm. At first sight this might seem to hurt customers. But do consumers really suffer from the strengthened market dominance of the high-quality firm? We next address this question by comparing the consumer surplus associated with uniform pricing with that associated with behavior-based pricing.

With uniform prices, the analysis of Section 3.1 implies that aggregate consumer welfare is

$$CW_0 \stackrel{\text{def}}{=} \int_0^{\frac{1}{3}} (\alpha x - p_A) dx + \int_{\frac{1}{3}}^1 (\beta x - p_B) dx = \frac{11\alpha - 2\beta}{18}, \quad (27)$$

where the prices  $p_A$  and  $p_B$  are substituted from (22). Next, the equilibrium under behavior-based pricing derived in Section 3.2, evaluated at an inherited market share

$x_0 = 1/3$ , yields the level of consumer welfare

$$\begin{aligned}
 CW_1 &\stackrel{\text{def}}{=} \int_0^{\frac{1}{9}} (\alpha x - p_A) dx + \int_{\frac{1}{9}}^{\frac{1}{3}} (\beta x - q_B) dx + \int_{\frac{1}{3}}^{\frac{4}{9}} (\alpha x - q_A) dx + \int_{\frac{4}{9}}^1 (\beta x - p_B) dx \\
 &= \frac{70\alpha + 11\beta}{162}, \quad (28)
 \end{aligned}$$

where the equilibrium prices are substituted from (24) and (25). Subtracting (27) from (28) yields  $CW_1 - CW_0 = 29(\beta - \alpha)/162 > 0$ . Hence,

**Result 9.** *The implementation of behavior-based pricing not only enhances the dominance of the high-quality seller, but it also promotes consumer welfare.*

Result 9 implies that the increase in dominance by itself is not harmful to consumers. However, the competition authorities may still want to monitor the dominant firm to ensure that it does not abuse its dominant position to lessen competition. Furthermore, when evaluating Result 9 it should be emphasized that in our model increased dominance of the high-quality firm does not change the market structure. Of course, the welfare conclusion could easily be different if increased dominance for the high-quality brand would induce exit of the low-quality brand.

## 4. Conclusion

Our analysis reveals that behavior-based pricing will not necessarily promote the persistence of market dominance, but rather enhance the intensity of competition. With horizontal product differentiation market dominance does not persist unless the dominant firm is protected by switching costs. While we find little reasons for concerns about increasing dominance in markets with horizontal product differentiation, such concerns are potentially better justified in markets with vertical differentiation. High quality producers can enhance dominant positions, but only by pricing more aggressively (in equilibrium).

We provide an example with vertical product differentiation, where increasing dominance is actually welfare increasing.

Overall the ability to price discriminate on the basis of purchase histories tends to transfer producer surplus into consumer surplus, although distributional effects also do occur. A ban on behavior-based pricing typically benefits loyal consumers and hurts newly entering consumers. Accordingly, welfare assessments will typically depend on the speed of market dynamics (i.e., the proportion of new consumers) and the relative weight of new and old consumers in the welfare judgment.

Our analysis has been restricted to horizontal or vertical differentiation models with the special feature of inelastic demand at the industry level. Our general conclusion is that behavior-based pricing tends to intensify competition within such a framework. This conclusion would be reinforced if we incorporate demand expansion effects, because the returns from the poaching activities would then be further stimulated by the option of attracting new, unattached consumers. Thus, in the presence of such demand effects the poaching incentives would be even stronger, thereby reducing the persistence of dominance.

It is worth relating our analysis also to another class of relevant studies about dynamic pricing. For example Caminal and Matutes (1990) derive equilibrium configurations where firms offer loyalty discounts, and do not charge loyalty premia.<sup>3</sup> An essential feature in that approach is that lower prices are applied to loyal customers than to customers who switch supplier. In this type of models loyalty discounts are a device to endogenously generate switching costs. An essential feature in this type of models is that firms commit to the discount schedule upfront, so that the consumers take this commitment into account when choosing with which supplier to establish a business relationship. Thus, compared to our model this approach exhibits a completely divergent intertemporal structure of the price equilibrium. It remains an interesting challenge for future research to explore under which circumstances price commitments would and could emerge as an equilibrium outcome.

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<sup>3</sup>Caminal and Claiici (2007) have recently developed that analysis further.

Throughout this study we have analyzed the implications of behavior-based pricing on the ability of a dominant firm to maintain and possibly strengthen its dominance within the framework of a limited horizon. Of course, from a theoretical perspective the strategic interaction between the dominant firm and the weak firm could continue for many periods. Within such a framework one could investigate the dynamics of dominance and, in particular, characterize the market shares towards which the process would converge. Of course, such an analysis would quickly be extremely complicated if the firms are able to maintain information on customer histories consisting of several periods. Our present analysis could be viewed as imposing a restriction on the firms so that these are able to maintain records of customer histories only for limited periods of time.

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