Market Dominance and Behavior-based Pricing under Horizontal and Vertical Differentiation*

Thomas Gehrig†
University of Freiburg
and CEPR

Oz Shy‡
University of Haifa, WZB,
and University of Michigan

Rune Stenbacka§
Hanken School of Economics, Helsinki

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Abstract

We analyze behavior-based price discrimination from an antitrust perspective by focusing on an industry with inherited market dominance. Under horizontal differentiation persistence of dominance requires that the dominant firm is protected by sufficiently significant advantages in switching costs or production costs. When an incumbent faces an entrant with no access to consumers' purchase histories the degree of dominance persistence is invariant across the regimes with behavior-based pricing and uniform pricing. Under vertical differentiation, the lock-in effects of customer relationships are quality-contingent. We characterize when market dominance persists for the high-quality firm with behavior-based pricing and compare with uniform pricing.

Keywords: Market Dominance, Behavior-based pricing, Consumer loyalty, Poaching, Price discrimination, Horizontal and vertical differentiation.

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†E-mail: thomas.gehrig@vwl.uni-freiburg.de. Institut zur Erforschung der Wirtschaftlichen Entwicklung Freiburg, Germany.

‡E-mail: ozshy@ozshy.com. Department of Economics, University of Michigan, Ann Arbor, MI 48109–1220, U.S.A.

§E-mail: Rune.Stenbacka@hanken.fi. Hanken School of Economics, P.O. Box 479, 00101 Helsinki, Finland.

1. Introduction

In today's business environment firms have access to technologies which enable them to price discriminate according to observed 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 based on purchase histories and ask how the strategic use of pricing schemes targeted to loyal customers affects industry performance. In particular we ask the following questions: Does the business practice of behavior-based price discrimination serve as a strategic device to make inherited market dominance persistent? What is precisely the relationship between behavior-based prices and uniform prices, and how does an inherited market share asymmetry affect this relationship? Can behavior-based price discrimination serve as an instrument for a dominant firm to induce exclusion of a smaller competitor or limit the sales of a smaller rival to such an extent that consumers suffer? 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. Even though we make use of a terminology which explicitly refers to the arena of European antitrust policy, the underlying economic issue is nevertheless also highly relevant from a US perspective. Namely, in US

competition law the Clayton Act implies that price discrimination is illegal if it substantially eliminates competition or if it promotes the creation of a monopoly in any line of commerce.

A number of European antitrust cases have established how price discrimination by purchase history might facilitate predation in a way which would, according to competition authorities or courts, qualify as an abuse of a dominant market position. The seminal case exemplifying this is the ECS/AKZO case[1], where AKZO targeted selective price cuts to ECS's customers with the intention of excluding ECS from the market. According to the decision of the European Commission "the anticompetitive effect of AKZO's differential pricing involved not so much indirect injury to customers but rather a serious impact on the structure of competition at the level of supply by reason of its exclusionary effect" (Section 83 of the European Commission's Decision on the ECS/AKZO case).[2] Another example is the Irish Sugar case, where the Commission fined Irish Sugar in 1997 for abuse of its dominant position in the national sugar market. The fined corporation applied a scheme of target rebates such that the rebate was more favorable to particular customers of competing sugar packers. This case was upheld by the European Court of First Instance in the case Irish Sugar v Commission[3], where the Court supported the Commission's finding that the selective price cut to border customers restricted competition in an illegal way, and that the selective price cut by Irish Sugar to its rival's customers, had it been proven, would have been considered an abuse of a dominant position. For a more extensive and systematic account of European competition law towards price discrimination we refer to Geradin and Petit (2005).

The Swedish Competition Authority vs TeliaSonera is a national competition case from year 2005 illustrating how selective poaching offers by a dominant firm to customers of a

[1]European Commission Decision 85/609 of 14 December 1985, ECS/Akzo, OJ L 374 of 31 December 1985, 1-27.

[2]The ECS/AKZO case actually exemplifies how price discrimination may facilitate predation. Spector (2005) presents a more thorough discussion of this aspect.

[3]European Court of First Instance, Irish Sugar plc v Commission, 7 October 1999, T-228/97, ECR [1999].

small rival may qualify as an abuse of market dominance. This case focuses on fixed line telecommunication as the relevant market, where TeliaSonera had a dominant position in the Swedish market. In this case TeliaSonera directed selective poaching offers exclusively to customers of Bredbandsbolaget, a small rival.[4]

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.[5] 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 weak 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.

With the exception of Chen (forthcoming) the literature cited above has analyzed various implications of behavior-based price discrimination within the framework of sym-

[4]Stockholm District Court Case 28 October 2005 Dnr 873/2005. Subsequently, The Swedish Competition Authority withdrew the case from the Market Court because the case could not be supported by convincing empirical evidence.

[5]Fudenberg and Villas-Boas (2006) present an updated survey on the literature focusing on behavior-based price discrimination.

metric oligopolies. However, as was illustrated by the European antitrust examples above, the potential abuse of a dominant market position is not really an issue from the point of view of antitrust policy unless we focus on an asymmetric industry structure, where one firm is equipped with a dominant position. In this paper we therefore assume that market dominance is exogenously inherited. Within such a framework we explore how well behavior-based pricing serves as an instrument for making a firm's inherited market dominance persistent.

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-based discriminatory schemes. Overall, the persistence of dominance is determined by three factors: Asymmetries in the switching costs, asymmetries in the production costs and the degree of inherited market dominance. 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 if there are no efficiency differentials between the incumbent and the entrant. Interestingly, the degree of persistence of market dominance of an incumbent facing entry is invariant across the regimes with behavior-based pricing and uniform pricing.

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 market dominance persists for the high-quality firm

as long as the cost difference between the high-quality and low-quality product is sufficiently smaller than the associated benefit to consumers even in the absence of any switching costs. In particular, with no cost differentials, the application of behavior-based pricing would translate into a higher degree of dominance for the high-quality supplier than the application of uniform pricing. This captures the idea that in equilibrium with behavior-based pricing 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: Ignoring cost considerations, 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.

Chen (forthcoming) presents a general dynamic model of behavior-based pricing with an asymmetric duopoly. He focuses mainly on characterizations of the dynamic price equilibria and some important welfare effects. Rather than studying the properties of the dynamic price equilibria as in Chen (forthcoming), we explore the persistence of dominance with behavior-based pricing within the framework of models with more structure with a particular focus on horizontal or vertical product differentiation. In particular, we explore the consequences of the use 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. Further, we distinguish between the consequences of behavior-based pricing in horizontally differentiated industries from those of vertically differentiated industries. Armstrong and Vickers (1993) and Bouckaert, Degryse and van Dijk (2007) 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. This distinction is important because there is a significant difference between offering low targeted prices to existing customers of rivals rather than to exogenously determined market segments which are more competitive than other segments.

When evaluating the antitrust implications of price discrimination an influential recent research approach, including, for example, Innes and Sexton (1994) and Karlinger and Motta (2007), seems to persistently emphasize the following tradeoff. On the procompetitive side, for an oligopolistic industry operating within a given market structure, price discrimination intensifies competition. On the anticompetitive side, price discrimination promotes exclusion of a weaker rival, because the dominant firm can induce exclusion by targeting competitive price offers to limited market segments, which makes it possible for the dominant firm to achieve exclusionary effects at lower costs. Our results regarding behavior-based prices discrimination are perfectly consistent with this view as far as the procompetitive aspects are concerned. However, our results do not support this view as far as the anticompetitive aspects are concerned. In this respect we find that the degree of persistence of market dominance of an incumbent facing entry is invariant across the regimes of with behavior-based pricing and uniform pricing.

Our study is divided into two parts: Section 2 explores the performance of behavior-based pricing as an instrument to make market dominance persistent 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. Section 4 concludes.

2. Pricing under Horizontal Product Differentiation

In this section we focus on horizontally differentiated firms. The firms compete with respect to behavior-based pricing schemes. We initially focus on competition in asymmetric duopolies where the dominant firm has inherited either weak (Section 2.1) or strong (Section 2.2) dominance. Section 2.3 compares the equilibrium under behavior-based pricing under weak dominance with that associated with uniform pricing. In Section 2.4 we study a market structure where the dominant firm can apply behavior-based pricing when facing an entrant with no access to customer histories.

Firms A and B produce differentiated brands. Firm A (B) is located on the left (right) side of the unit interval. 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.

Firm A's and B's unit production costs are denoted by c_A and c_B. 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 σ_{AB} (σ_{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

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

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 β measures the consumer's basic satisfaction. The parameter $\tau \geq 0$ is the "transportation cost" parameter. A low value of τ will be interpreted as intense brand competition. The brand switching cost parameters σ_{AB} and σ_{AB} can be interpreted to capture, for example, network externalities, compatibility, or learning costs.

We will be making use of the following terminology.

DEFINITION 1. *Let,* $\Delta c \stackrel{\text{def}}{=} c_A - c_B$, *and* $\Delta\sigma \stackrel{\text{def}}{=} \sigma_{AB} - \sigma_{BA}$. *We say that*

(a) Firm B *is more efficient than firm* A *if* $\Delta c > 0$.

(b) Firm A *has a switching cost advantage over firm* B *if* $\Delta\sigma > 0$.

Thus, $\Delta c > 0$ implies that $c_A > c_B$ which means that firm B has a production cost advantage. Also, $\Delta\sigma > 0$ implies that consumers find it more costly to switch from brand A to brand B than from brand B to brand A.

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.

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

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

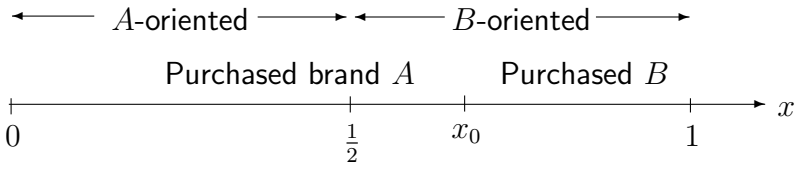

Figure 1: Characterization of purchase history.

(b) Firm A's initial market share (purchase history) satisfies

$$\max\left\{-\frac{1}{2}-\frac{\sigma_{AB}+\Delta c}{2\tau}\ ;\ \frac{1}{2}\right\} < x_0 < \min\left\{1\ ;\ \frac{3}{2}+\frac{\sigma_{AB}-\Delta c}{2\tau}\right\}.$$

As previously discussed, there is no loss of generality by assuming that $0.5 < x_0 < 1$. The rest of Assumption 1(b) is not essential except for limiting our analysis to interior solutions as described in Figure 2 below. Observe that Assumption 1(b) is always satisfied for sufficiently low values of Δc. We now classify purchase history as follows.

DEFINITION 2. *We say that the purchase history x_0 exhibits* **weak dominance** *if $x_0 < \bar{x}_0$ and* **strong dominance** *if $x_0 \geq \bar{x}_0$, where*

$$\bar{x}_0 \stackrel{\text{def}}{=} \frac{3}{4}+\frac{2c_A+c_B-\sigma_{BA}}{4\tau}.$$

Figure 2 illustrates an equilibrium allocation of consumers under weak dominance. The

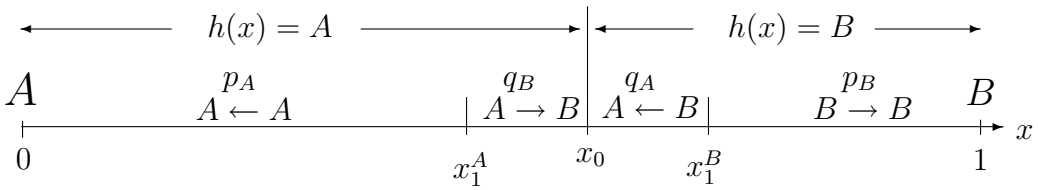

Figure 2: Consumer allocation between horizontally-differentiated brands under weak dominance. *Note*: Arrows indicate consumers' choice in each segment.

left segment in Figure 2 illustrates consumers who are loyal to 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 contrast to Figure 2, Figure 3 illustrates this configuration under strong dominance. Strong dominance eliminates the range of consumers indexed on the interval $[x_0, x_1^B]$ in

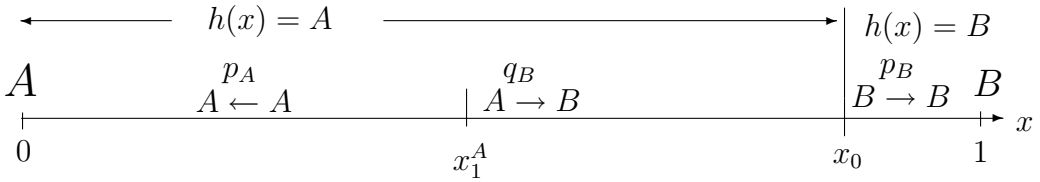

Figure 3: Consumer allocation between horizontally-differentiated brands under strong dominance.

Figure 2. Therefore, in equilibrium the dominant firm A is unable to induce switching because its poaching activities would have to win consumers located much closer to firm B.

Our computations reveal that not much intuition can be gained from presenting both cases which are described in Definition 2. Therefore, in what follows we focus mostly on characterizing the equilibria under weak dominance.

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,

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

Equation (2) defines a new allocation of consumers between the brands as illustrated in Figure 2.

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

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

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

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

and poaching prices

$$q_A = \frac{\tau(3 - 4x_0) - \sigma_{BA} + 2c_A + c_B}{3} \quad \text{and} \quad q_B = \frac{\tau(4x_0 - 1) - \sigma_{AB} + 2c_B + c_A}{3}. \tag{5}$$

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

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

Assumption 1(a) guarantees that $x_1^A < x_1^B$ whereas Assumption 1(b) ensures that $x_1^A > 0$ and $x_1^B < 1$. 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

$$m_1^A = x_1^A + (x_1^B - x_0) = \frac{2 - x_0}{3} + \frac{\Delta\sigma - 2\Delta c}{6\tau}. \tag{7}$$

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

$$m_1^B = 1 - x_1^B + x_0 - x_1^A = \frac{1 + x_0}{3} - \frac{\Delta\sigma - 2\Delta c}{6\tau}. \tag{8}$$

Comparing (7) with (8) yields

Result 1. *With behavior-based price discrimination,*

(a) Market dominance persists ($m_1^A > \frac{1}{2}$) if $\Delta\sigma > 2\tau(x_0 - \frac{1}{2}) + 2\Delta c$.

(b) Market dominance is broken ($m_1^A \leq \frac{1}{2}$) if $\Delta\sigma \leq 2\tau(x_0 - \frac{1}{2}) + 2\Delta c$.

In light of Result 1 we can conclude that the persistence of dominance is determined by three forces: asymmetries in the switching costs, asymmetries in the transportation costs and asymmetries in the production costs. We initially comment on Result 1(a) by focusing on a configuration with equally efficient firms, i.e., with $\Delta c = 0$. With $\Delta c = 0$ 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 inherited asymmetric market shares. It should be emphasized that what matters here is the relative switching costs. Market dominance is always reversed in the special case with $\sigma_A = \sigma_B$.

Intuitively, with inherited asymmetric market shares there is a tendency for the small firm to defend its inherited customer relationships with more aggressive pricing (as seen by (4)). 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 induce persistent dominance unless it is combined with another sufficiently strong strategic advantage like higher switching costs.

What is the effect of firm-specific efficiency differences on dominance persistence? From Result 1(a) we can conclude that a stronger efficiency disadvantage for the dominant firm induces a higher threshold with respect to the required switching cost advantage for dominance to persist. In other words, the switching cost advantage required for dominance to persist is lower the higher is the relative production efficiency of the dominant firm compared with the small firm.

Figure 4(left) illustrates the difference in brand-specific switching costs required for persistence of market dominance. The Figure 4(left) is drawn for the case with no efficiency differential between the firms, i.e., for the case with $\Delta c = 0$.

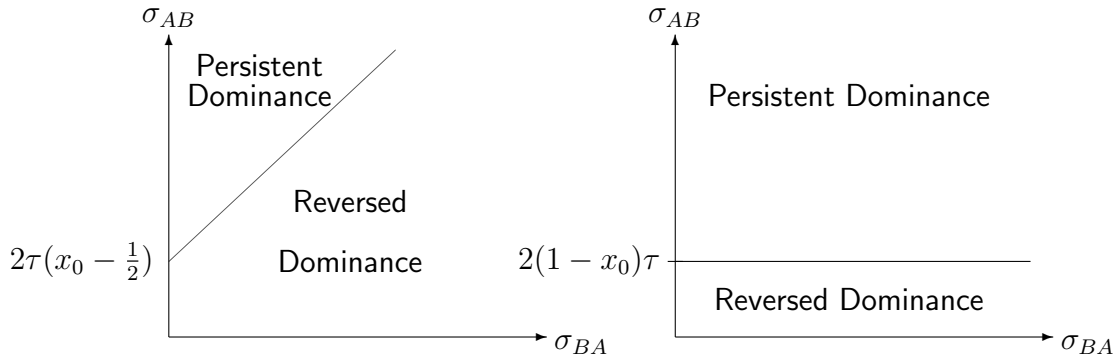

Figure 4: The effect of brand specific switching costs on persistence of dominance. *Left*: Weak dominance. *Right*: Strong dominance.

Figure illustrates the difference in switching costs required for persistence of market dominance as a function of the inherited market share dominance . Figure 5 is drawn for

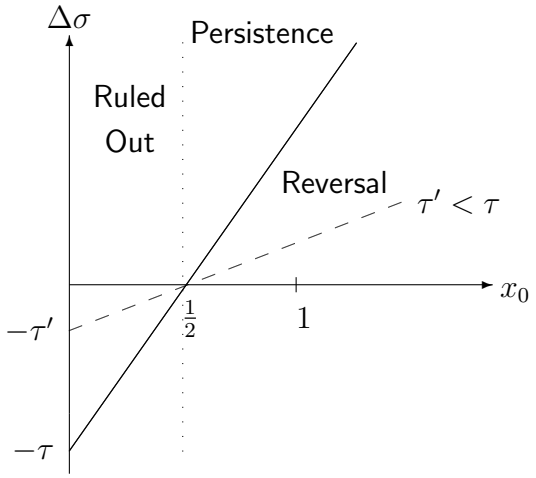

Figure 5: Persistence versus reversal of market dominance. *Note*: A clockwise rotation reflects a decrease in τ.

the case with $\Delta c = 0$. In line with Result 1(a), Figure 5 illustrates that a *lower* τ expands the segment of persistent dominance. In fact, it follows directly from (4) and (5) that

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

That is, a decline in τ 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 τ) 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

In Section 2.1 we focused on inherited weak dominance. We will now shift our attention to the configuration with strong dominance. In order to highlight the main difference between weak and strong dominance as transparently as possible we restrict ourselves to the case with equally efficient firms, i.e., the case with $\Delta c = 0$

Suppose now that $3/4 - \sigma_{BA}/(4\tau) < x_0 < 1$, which by Definition 2 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 because its poaching activities would have to win consumers located much closer to firm B. Figure 3 illustrates this configuration.

To compute the equilibrium prices supporting the configuration illustrated in Figure 3, we set firm A's poaching price to equal marginal cost, $q_A = 0$. Comparing Figure 3 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

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

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 4. Finally, observe that similar to Figure 5, an increase in the intensity of competition (a lower τ) 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 on the persistence of dominance in particular, this section briefly characterizes the price equilibrium with uniform pricing. Again, in order to make the comparison between behavior-based pricing and uniform pricing as transparent as possible we restrict ourselves to the case with equally efficient firms $\Delta c = 0$ for the case with inherited 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.

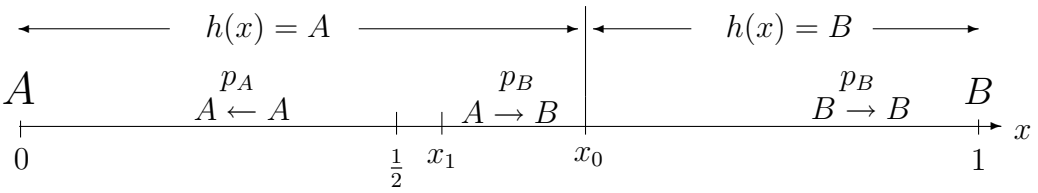

Figure 6: Consumer allocation between horizontally-differentiated brands under uniform pricing.

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

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

Notice that σ_{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 $\pi_A = p_A(1-x_1)$. The unique Nash-Bertrand equilibrium in prices and firm A's market share are given by

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

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 the 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 σ_{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

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

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. 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.

Consider a market in which the incumbent firm A inherits full market coverage, so $x_0 = 1$. Suppose now that a fraction θ 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. Thus, the incumbent has no particular advantage or disadvantage with respect to the new customers. 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.[6] Firm B cannot distinguish among consumers, so it sets a single price p_B to all consumers (new

[6]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.

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 $\beta - p_A - \tau x_1 = \beta - p_B - \tau(1 - x_1) - \sigma_{AB}$. Therefore,

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

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

$$p_A = \tau + \frac{(2+\theta)\sigma_{AB} + 4c_A + 2c_B}{6}, \quad q_A = \tau + \frac{4c_A + 2c_B - (1-\theta)\sigma_{AB}}{6},$$
$$\text{and} \quad p_B = \tau + \frac{2c_B + c_A - (1-\theta)\sigma_{AB}}{3}. \tag{16}$$

Notice that $p_A > q_A > p_B$ meaning that the entrant adopts a very aggressive pricing strategy buy 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,

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

From (17) we can directly formulate the following result.

Result 6. *If $\sigma_{AB} > \Delta c/(1-\theta)$, an incumbent applying behavior-based price discrimination can maintain market dominance ($m_1^A > 1/2$) despite entry.*

From Result 6 we can draw a number of significant and interesting conclusions. Firstly, if the incumbent is more efficient than the entrant ($\Delta < 0$) dominance will always persist. This is a natural result and under such circumstances the persistence of dominance does not seem to pose serious antitrust concerns. Secondly, when the firms are equally efficient ($\Delta = 0$) the incumbent is able to defend its dominance through the use of behavior-based

pricing as long as it is protected by some level of switching costs. Thirdly, and perhaps most interestingly, even when facing a more efficient entrant ($\Delta < 0$) an incumbent protected by sufficiently strong switching costs can maintain dominance through the use of behavior-based price discrimination.

It should be emphasized that the persistence of dominance for an incumbent is here discussed in the absence of any sunk entry costs for the entrant. In practice, the potential exclusionary effects of behavior-based pricing would have to take such effects into account. In any case, Result 6 is very interesting when evaluating whether behavior-based price discrimination could qualify as an abuse of a dominant position in light of the "as efficient competitor-test, which is sometimes advocated by the European Commission.[7]

How does behavior-based price discrimination on behalf of the incumbent perform compared with a configuration where the incumbent is restricted to uniform pricing? Formally, by re-computing the price equilibrium (p_A^u, p_B^u) subject to the restriction that the incumbent operates with a uniform price precisely like the entrant we find that

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

Based on this equilibrium in uniform prices we find that the market share of the incumbent is given by

$$m_A^u = \theta x_n^u + (1-\theta)x_1^u = \frac{1}{2} + \frac{(1-\theta)\sigma_{AB} - \Delta c}{6\tau} > \frac{1}{2}. \quad (19)$$

From (19) and (17) we can draw the following conclusion.

Result 7. *The persistence of market dominance for an incumbent firm is invariant across the regimes with behavior-based pricing and uniform pricing.*

[7] For example, in its public discussion paper on the application of Article 82 to exclusionary abuses in December 2005 the European Commission (see, `http://ec.europa.eu/comm/competition/antitrust/art82/discpaper2005.pdf`) evaluates some business practices against the criterion that only conduct which would exclude a hypothetical "as efficient competitor would be abusive.

Result 7 means that an incumbent applying behavior-based price discrimination can defend market dominance precisely under the same circumstances when this incumbent can maintain dominance if restricted to uniform pricing. In this respect behavior-based price discrimination does not promote the persistence of an incumbent's dominance. As far as market shares are concerned we can conclude that the market discipline imposed by the entrant's uniform price is equally efficient independently of whether the incumbent operates with a uniform price or with behavior-based pricing. However, this does not mean that the price equilibrium would be unchanged across the two pricing systems.

Comparing (18) with (16) reveals that $p_A > p_A^u$, $q_A > p_A^u$, and $p_B = p_B^u$, implying that behavior-based price discrimination has distributional effects across different consumer segments. More precisely, consumers loyal to the incumbent are better off with uniform pricing, whereas new consumers buying from the incumbent prefer behavior-based pricing. Furthermore, consumers buying from the entrant are indifferent between uniform and behavior-based pricing.

2.5 Behavior-based Pricing under Horizontal Differentiation: Main Findings

We initially designed a model with inherited market dominance in an industry where two firms, the dominant firm and the small firm, can price discriminate between consumers based on purchase history. Our analysis established that with horizontal product differentiation behavior-based price discrimination does not lead to persistent market dominance unless it is combined with another sufficiently strong strategic advantage like higher switching costs. The degree of inherited market dominance (weak or strong), the relative production efficiencies and the degree of switching cost advantage are the crucial factors determining whether dominance persists. Furthermore, the equilibrium market share of the firm with inherited dominance is lower when firms compete with behavior-based pricing compared with the configuration when firms compete with uniform prices. Overall, behavior-based pricing tends to intensify competition compared with uniform pricing.

We also studied a market structure where the dominant firm can apply behavior-based pricing to compete against an entrant with no access to consumers' purchase histories. Under such circumstances an incumbent facing an equally efficient entrant is able to defend its dominance with behavior-based pricing only as long as it is protected by some switching costs. We also explored how efficiency differentials between the incumbent and the entrant affect the switching cost threshold needed for dominance to persist. Finally, we established that the persistence of market dominance for an incumbent firm is invariant across the regimes with behavior-based pricing and uniform pricing.

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 Uniform pricing under vertical differentiation

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

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \alpha x - p_L & \text{if buys brand } L \\ \beta x - p_H & \text{if buys brand } H, \end{cases} \quad \text{where} \quad \beta > \alpha > 0, \tag{20}$$

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

We assume firm H (firm L) to have marginal costs and these marginal costs satisfy $\Delta c = c_H - c_L > 0$. Furthermore, we assume that $\Delta c < \beta - \alpha$. In the absence of behavior-based pricing, firm L chooses a single price p_L to maximize $\pi_L = (p_L - c_L)\hat{x}$ and firm H chooses p_H to maximize $\pi_H = (p_H - c_H)(1 - \hat{x})$, where $\hat{x}(p_L, p_H)$ is determined by $\alpha\hat{x} - p_L = \beta\hat{x} - p_H$. The equilibrium market share of firm L is given by

$$\hat{x} = \frac{1}{3} - \frac{\Delta c}{3(\beta - \alpha)}. \tag{21}$$

Therefore, with uniform pricing the high-quality firm captures the market share $1 - \hat{x} = 2/3 + \Delta c/[3(\beta - \alpha)]$. In particular, for the special case with $\Delta c = 0$ the high-quality firm would charge a price which is double relative to the low-quality firm, and the high-quality firm would have the market share $2/3$.

3.2 Behavior-based pricing under vertical differentiation

We now investigate the persistence of the high-quality firm's (H's) market dominance if both firms have access to the option of behavior-based pricing. Figure 7 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 7 reflects a situation where the high-

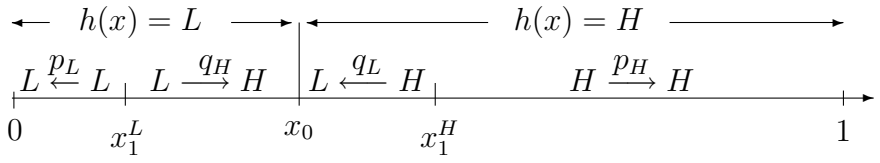

Figure 7: Consumer allocation between vertically-differentiated brands.

quality firm H inherits a larger market share than the low-quality firm L (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 7 and given the purchase history parameter x_0, in the absence of switching costs the utility functions (22) are now given by

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \alpha x - p_L & \text{if } h(x) = L \text{ and continues to purchase brand } L \\ \beta x - q_H & \text{if } h(x) = L \text{ and switches to brand } H \\ \beta x - p_H & \text{if } h(x) = H \text{ and continues to purchase brand } H \\ \alpha x - q_L & \text{if } h(x) = H \text{ and now switches to brand } L, \end{cases} \tag{22}$$

where, as before, $\beta > \alpha > 0$ indicate that brand H is the high-quality brand. In view of Figure 7, (22) implies that x_1^L is determined from $\alpha x_1^L - p_L = \beta x_1^L - q_H$, and x_1^H from $\alpha x_1^H - q_L = \beta x_1^H - p_H$. Therefore, $x_1^L = (q_H - p_L)/(\beta - \alpha)$ and $x_1^H = (p_H - q_L)/(\beta - \alpha)$.

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

$$p_L = \frac{(\beta - \alpha)x_0 + 2c_L + c_H}{3} \quad \text{and} \quad p_H = \frac{(\beta - \alpha)(2 - x_0) + 2c_H + c_L}{3}, \tag{23}$$

and the equilibrium poaching prices

$$q_L = \frac{(\beta - \alpha)(1 - 2x_0) + 2c_L + c_H}{3} \quad \text{and} \quad q_H = \frac{(\beta - \alpha)2x_0 + 2c_H + c_L}{3}. \tag{24}$$

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

$$x_1^L = \frac{x_0}{3} + \frac{\Delta c}{3(\beta - \alpha)}, \quad x_1^H = \frac{x_0 + 1}{3} + \frac{\Delta c}{3(\beta - \alpha)},$$
$$\text{and} \quad m_1^L = \frac{1 - x_0}{3} + \frac{2\Delta c}{3(\beta - \alpha)}, \quad \text{and} \quad m_1^H = \frac{x_0 + 2}{3} - \frac{2\Delta c}{3(\beta - \alpha)}, \tag{25}$$

where $m_1^L = x_1^L + (x_1^H - x_0)$ and $m_1^H = (1 - x_1^H) + (x_0 - x_1^L)$.

Let us now focus on a configuration where firm H has inherited dominance, i.e., $x_0 < 1/2$. From (25) we can directly draw the following conclusion.

Result 8. *With behavior-based pricing, market dominance persists ($m_1^H > 0.5$) for the high-quality firm if*

$$\frac{\Delta c}{\beta - \alpha} < \frac{2x_0 + 1}{4}, \tag{26}$$

In light of (26) we can infer that market dominance persists for the high-quality firm as long as the cost-benefit ratio $\Delta c/(\beta - \alpha)$ of high-quality production is not too close to

one. Interestingly, under condition (26) the high-quality firm can maintain its dominance independently of whether it has any switching cost protection at all. This is an interesting feature in comparison with the model of horizontal product differentiation, where, as we showed in Section 2.1, the dominant firm cannot defend its dominance unless it is protected by a sufficiently strong switching cost advantage. In particular, if $\Delta c = 0$ we can conclude that a dominant high-quality supplier would always be able to defend its dominance with behavior-based pricing.

Let us explore the opposite scenario in which the low-quality firm has inherited dominance so that $x_0 > 0.5$. Under such circumstances it is straightforward to establish the following result.

Result 9. *With behavior-based pricing inherited market dominance persists ($m_1^L > 0.5$) for the low-quality firm if*

$$\frac{\Delta c}{\beta - \alpha} > \frac{2x_0 + 1}{4}. \tag{27}$$

In light of Results 8 and 9 we can conclude that the lock-in effects of established customer relationships are quality-contingent with behavior-based pricing. By comparing Results 8 and 9 we find that market dominance persists either for the high-quality or for the low-quality producer. Market dominance can persist for the low-quality firm only if the cost-benefit ratio $\Delta c/(\beta - \alpha)$ is sufficiently large. If $\Delta c = 0$, low-quality supplier would never be able to maintain its dominance by using behavior-based pricing. In other words, the dominance of low-quality incumbents requires that the quality improvements are moderate relative to cost differentials.

How does behavior-based price discrimination on behalf of the high-quality firm perform compared with a configuration where the high-quality supplier is restricted to uniform pricing? Again, consider a situation where the high-quality firm has inherited dominance in the form of a market share $1 - x_0$ with $x_0 < 1/2$. Under such circumstances application of behavior-based pricing will induce a higher market share for the high-quality firm than

application of uniform pricing if

$$m_1^H = \frac{x_0 + 2}{3} - \frac{2\Delta c}{3(\beta - \alpha)} > \frac{2}{3} + \frac{\Delta c}{3(\beta - \alpha)} = 1 - \hat{x}, \tag{28}$$

where $\hat{x}$ is defined in (21). Condition (28) is equivalent to the condition $x_0 > 3\Delta c/(\beta - \alpha)$. The following result summarizes this finding.

Result 10. *When inherited market share is sufficiently large relative to the cost-benefit-ratio associated with the quality improvement, that is, when $x_0 > 3\Delta c/(\beta - \alpha)$, behavior-based pricing induces stronger dominance than uniform pricing. To the converse, when the cost-benefit-ratio associated with the quality improvement is sufficiently small, that is, $x_0 < 3\Delta c/(\beta - \alpha)$, uniform pricing implies stronger dominance.*

Consequently, the issue of whether behavior-based pricing induces a higher market share for the dominant firm depends on two factors: the degree of inherited dominance and the cost-benefit ratio of associated with the quality improvement.

In particular, if $\Delta c = 0$ we can see that the application of behavior-based pricing would translate into a higher degree of dominance for the high-quality supplier than the application of uniform pricing. In Appendix A we explore the consequences for consumer welfare of an enhanced degree of dominance generated by the application of behavior-based pricing by the high-quality supplier in the case with $\Delta c = 0$. Appendix A demonstrates that behavior-based pricing would promote consumer welfare even though it makes the degree of market dominance stronger. Thus, the calculation incorporated in this Appendix implies that an increased degree of dominance need not by itself be harmful to consumers.

4. Conclusion

We initially designed an asymmetric duopoly model with inherited market dominance in an industry where two firms, the dominant firm and the small firm, can price discriminate between consumers based on their purchase history. We demonstrated that with horizontal

product differentiation behavior-based price discrimination does not lead to persistent market dominance unless it is combined with another sufficiently strong strategic advantage like higher switching costs. We found that the persistence of dominance crucially depends on the degree of inherited market dominance (weak or strong), the relative production efficiencies and the relative switching costs. Furthermore, the equilibrium market share of the firm with inherited dominance was shown to be lower when firms compete with behavior-based pricing compared with the configuration where firms compete with uniform prices. Overall, behavior-based pricing tends to intensify competition compared with uniform pricing. While we found 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 suppliers can persistently defend dominant positions, but only by pricing more aggressively (in equilibrium). We presented an example with vertical product differentiation, where increasing dominance is actually welfare increasing.

We distinguished asymmetric competition with behavior-based pricing schemes from a market structure where the dominant firm applies behavior-based pricing to compete against an entrant with no access to consumers purchase histories. Under such circumstances our analysis established that an incumbent facing an equally efficient entrant is able to defend its dominance with behavior-based pricing only as long as it is protected by some switching costs. We also characterized how the switching cost threshold needed for dominance to persist depends on the efficiency differential between the incumbent and the entrant. Finally, we established that the persistence of market dominance for an incumbent firm is invariant across the regimes with behavior-based pricing and uniform pricing. This feature does not seem to support the widespread view according to which price discrimination promotes exclusion of a weaker rival.

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.[8] 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.

Throughout this study we have analyzed the implications of behavior-based pricing on the ability of a dominant firm to maintain, or 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,

[8] Caminal and Claici (2007) have recently developed that analysis further.

in particular, characterize the market shares towards which the process would converge.[9] 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.

Appendix A. Welfare analysis under vertical differentiation

Let us focus on the case with $\Delta c = 0$. As (28) shows, under such circumstances the application of behavior-based pricing would translate into a higher degree of dominance for the high-quality supplier than the application of uniform pricing.

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

$$CW_0 \stackrel{\text{def}}{=} \int_0^{\frac{1}{3}} (\alpha x - p_A)dx + \int_{\frac{1}{3}}^1 (\beta x - p_B)dx = \frac{11\alpha - 2\beta}{18}, \tag{29}$$

where the prices p_A and p_B are substituted from (21). 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

$$CW_1 \stackrel{\text{def}}{=} \int_0^{\frac{1}{9}} (\alpha x - p_A)dx + \int_{\frac{1}{9}}^{\frac{1}{3}} (\beta x - q_B)dx + \int_{\frac{1}{3}}^{\frac{4}{9}} (\alpha x - q_A)dx + \int_{\frac{4}{9}}^1 (\beta x - p_B)dx$$
$$= \frac{70\alpha + 11\beta}{162}, \tag{30}$$

where the equilibrium prices are substituted from (23) and (24). Subtracting (29) from (30) yields $CW_1 - CW_0 = 29(\beta - \alpha)/162 > 0$. Hence,

[9] With respect to the dynamics of price equilibria and market shares Chen (forthcoming) and Beggs and Klemperrer (1992) have made valuable contributions. They have not, however, explored the antitrust implications and, in particular, they have not explored the consequences for persistence of dominance.

Result 11. *The implementation of behavior-based pricing not only enhances the dominance of the high-quality seller, but it also promotes consumer welfare.*

Result 11 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 11 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.

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