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A Welfare Evaluation of History-Based Price Discrimination

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ABSTRACT

We design an asymmetric duopoly model with inherited market dominance such that the dominant firm and the smaller firm can price discriminate based on consumers' purchase history. We show that uniform pricing softens competition leading to higher industry profits than under history-based pricing. Consumers benefit from history-based price discrimination unless the switching cost is sufficiently high and the inherited degree of dominance is sufficiently weak. A ban on history-based pricing would typically introduce a distributional conflict between consumers and producers. Finally, we establish that the gains to industry profits associated with uniform pricing exceed the associated losses to consumers.

Keywords: market dominance, history-based pricing, consumer loyalty, poaching, price discrimination, horizontal differentiation.

CONTENTS

1	INTRODUCTION.....	1
2	LITERATURE REVIEW	4
3	HISTORY-BASED PRICE DISCRIMINATION	7
3.1	Weak dominance.....	9
3.2	Strong dominance	11
4	UNIFORM PRICING	13
5	WELFARE ANALYSIS.....	16
5.1	Comparing uniform pricing with history-based pricing under weak dominance.....	16
5.2	Comparing uniform pricing with history-based pricing under strong dominance.....	23
6	CONCLUSION	26
	REFERENCES	30

FIGURES

Figure 1	Characterization of purchase history	7
Figure 2	Consumer allocation between horizontally-differentiated brands under weak dominance	9
Figure 3	Consumer allocation between horizontally-differentiated brands under strong dominance.....	10
Figure 4	Consumer allocation between horizontally-differentiated brands under uniform pricing.....	13
Figure 5	Differences in consumer surplus under weak dominance	17

1 INTRODUCTION

It has become common practice in many industries, for example, cable TV, telecommunication, service industries and energy industries, to apply history-based price discrimination, i.e. to differentiate the prices directed to old and new customers. Typically, new customers are targeted by aggressive price offers (introductory offers or poaching prices), which are designed to attract new customers or to induce rival firms' customers to switch even when those customers are already locked-in in another customer relationship. In this study we will conduct a welfare analysis of history-based price discrimination within the framework of an asymmetric duopoly model where the dominant firm as well as its small rival can apply history-based pricing. More precisely, we compare the effects of history-based price discrimination on consumer surplus and industry profits with those associated with uniform pricing within a framework, where consumers have differentiated preferences and face switching costs. Consequently, we analyze a model where the inherited history matters not only because of the information it conveys on consumer preferences, but also because switching costs directly affect profits and consumer surplus. We also explore to what extent history-based pricing can be viewed as an instrument for a dominant firm to induce exclusion of smaller rivals.

Competition lawyers and judges have tended to view history-based price discrimination conducted by a dominant firm, as any form of discrimination, in a rather sceptical, if not resentful, way (e.g. Möschel 1999). Such a view has often been based on a form-based approach to the implementation of competition law. A number of European antitrust cases have established how history-based price discrimination might facilitate predation in a way which would, according to competition authorities or courts, qualify as an abuse of a dominant market position. The ECS-AKZO case ¹ is the seminal case exemplifying this. AKZO directed poaching prices to ECS's customers with the intention of excluding ECS from the market. Spector (2005) presents a thorough discussion of this aspect. Another example is the Irish Sugar case, where the dominant firm applied a scheme of target rebates such that the rebate was more favourable to particular customers of competing sugar packers. The Swedish Competition Authority vs. TeliaSonera from year 2005 is another example illustrating how selective poaching offers by a dominant firm to a small rival's customers may qualify as an abuse of market dominance. In this case TeliaSonera directed selective poaching offers exclusively to customers of

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

Bredbandsbolaget, a small regional rival in the Swedish market for fixed line telecommunications.² For an extensive and systematic account of European competition law towards price discrimination see Geradin and Petit (2005).

In this study we adopt a standard Hotelling model to analyze the effects of history-based price discrimination in asymmetric industries, where one of the firms is assumed to have a dominant market position. We focus on a duopoly industry endowed

with an inherited position of dominance, where, for simplicity, dominance is assumed to mean a market share larger than 50%.³ We find that uniform pricing is a more powerful instrument than history-based pricing for the dominant firm to defend its market share advantage. We show that consumers benefit from history-based price discrimination unless the switching cost is sufficiently high. The switching cost threshold, above which consumers benefit from uniform pricing, depends on whether the inherited dominance is weak or strong. Uniform pricing softens competition in the duopolistic industry leading to higher industry profits under uniform pricing. Consequently, unless the switching costs are sufficiently large, a ban on history-based price discrimination would redistribute surplus from consumers to producers. Finally, we establish that the gains to industry profits associated with uniform pricing under all circumstances exceed the associated losses to consumers.

Our study has strong implications for competition policy, not only with respect to the implementation of Article 102 in Europe but also in light of US Section 2 of the Clayton Act, which renders any activity that aims at substantially eliminating competition or creating a monopoly as illegal per se. We find that a policy of banning history-based price discrimination leads to higher prices in most consumer segments, and, therefore, tends to reduce overall consumer surplus. Moreover, a ban on price history-based discrimination tends to soften competition and promote industry profits.

Our study is structured as follows:

- Section 2 presents a short literature review and identifies our contribution to this literature. The analytical part of our study is divided into three sections.

² Stockholm District Court Case 28 October 2005 Dnr 873/2005.

³ Of course, in competition law there is a general verbal characterization of market dominance. For example, the European Commission defines dominance to be a position of economic strength making it possible for the dominant undertaking to behave to an appreciable extent independently of its competitors and ultimately of its consumers.

- Section 3 presents a detailed equilibrium analysis of competition with history-based pricing.
- Section 4 characterizes the equilibrium with uniform pricing.
- Section 5 evaluates the welfare implications of history-based pricing.
- Section 6 concludes.

2 LITERATURE REVIEW

When exercised by a monopoly, price discrimination is a method by which the monopolist can extract surplus from consumers in order to enhance profits. As shown initially by Thisse and Vives (1988), the consequences of price discrimination change dramatically in an oligopoly. They demonstrate that when firms compete strategically with completely individualized prices (perfect price discrimination) competition is intensified relative to the outcome of competition with uniform prices, but their study explores the effects on competition of perfect price discrimination within the framework of a symmetric duopoly with no switching costs. In contrast, we focus on an asymmetric industry with inherited dominance and investigate the welfare effects of history-based price discrimination in the presence of switching costs.

In industries with switching costs firms have strategic incentives to establish business relationships. The business relationships are profitable because firms can exploit locked-in customers up to a limit determined by the switching costs. With history-based price discrimination firms poach their rivals' customers with competitive poaching offers, which are sufficiently much lower than the prices charged to loyal customers. However, the prices charged to both customer categories are below the equilibrium prices with uniform price schemes. Fudenberg and Tirole (2000) is a seminal contribution for a general analysis of history-based pricing, whereas Chen (1997), Taylor (2003), Gabrielsen (2004), Gehrig and Stenbacka (2004, 2007), Chen and Zhang (2009) and Esteves (2010) present more specialized symmetric duopoly models or applications of this type.⁴

The potential abuse of a dominant market position is not really an issue unless we focus on an asymmetric industry structure, where one firm is equipped with a dominant position. Contrary to the literature cited above, we therefore focus on an asymmetric industry structure with inherited dominance and explore the welfare implications of history-based pricing. Within the framework an asymmetric duopoly model, where consumers have firm-specific degrees of loyalty to their suppliers, Shaffer and Zhang (2000) demonstrate that history-based pricing may actually soften competition and involve a lower price to the firm's own customers. In this respect our model shows that

⁴ Fudenberg and Villas-Boas (2007) and Esteves (2009) present updated literature surveys on behaviour-based price discrimination. For a literature survey of price discrimination more generally we refer to Armstrong (2006).

history-based price discrimination intensifies competition and generates higher prices to loyal customers. Our model differs from the model studied by Shaffer and Zhang (2000) insofar as we focus on a differentiated Hotelling industry, whereas Shaffer and Zhang (2000) analyze a homogeneous industry which allows for no differences in the market elasticities of demand between the two competing brands. Chen (2008) presents a dynamic model of how behaviour-based pricing by a dominant firm may facilitate predation based on exit of a small rival. Chen conducts the analysis with an arbitrary time horizon and with a segmented market such that firms do not compete head-to-head when they apply uniform pricing and he characterizes the dynamic price equilibria and some welfare properties. Compared with Chen (2008), in this study we conduct a complete welfare analysis of history-based price discrimination in an asymmetric Hotelling model such that the loyal segment of the dominant firm's market is endogenously determined.

Most importantly, our study is related to a recent literature exploring the welfare effects of price discrimination. Esteves (2010) conducts a welfare analysis of history-based pricing within the context of a symmetric two-period model. Apart from its focus on a symmetric duopoly, Esteves (2010) differs from ours also insofar as firms apply mixed pricing strategies in the first period and consumers do not bear switching costs. Armstrong and Vickers (1993), Cheung and Wang (1999) and Bouckaert et al. (2007) study how bans on price discrimination by dominant firms affect entry and welfare. 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.

Relatedly, Gehrig et al. (2011) design a Hotelling model to analyze the effect of history-based price discrimination on entry and welfare in a configuration where the entrant has no access to information about consumers' purchase histories. Contrary to that study, here we conduct the welfare analysis of history-based price discrimination within the context of an asymmetric duopoly model where both the dominant firm and the smaller rival have access to information about consumers' purchase histories. By comparing our results from the present model with Gehrig et al. (2011) we can draw the general conclusion that the potential antitrust threats created by history-based pricing are sensitive to whether the dominant firm has exclusive access to information about consumers' purchase histories or not. As far as the welfare implications are concerned consumers

tend to benefit from history-based price discrimination if also the small firm can apply behaviour-based pricing, whereas history-based pricing reduces consumer surplus if the dominant firm has exclusive access to price discrimination.

Evaluations of the antitrust implications of price discrimination commonly emphasize the following trade-off, see for example Innes and Sexton (1994) and Karlinger and Motta (2007). For an oligopolistic industry operating within the framework of a given market structure, price discrimination intensifies competition, thereby promoting consumer welfare. On the other hand, with price discrimination the dominant firm can induce exclusion more effectively 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 policy conclusions from the present analysis are largely consistent with this view unless the switching costs are sufficiently high. Overall we find that the history-based pricing has a potential to facilitate predation if the switching costs are sufficiently low, and thereby history-based pricing may raise potential concerns for exclusionary abuse.

3 HISTORY-BASED PRICE DISCRIMINATION

We consider horizontally differentiated firms. The firms compete with respect to history-based pricing schemes. We focus on competition in an asymmetric duopoly where the dominant firm has inherited either weak (Section 3.1) or strong (Section 3.2) dominance to be defined below.

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 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 labelled $t = 0$ 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 in period $t = 1$. Let c denote the unit production cost of firms A and 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.

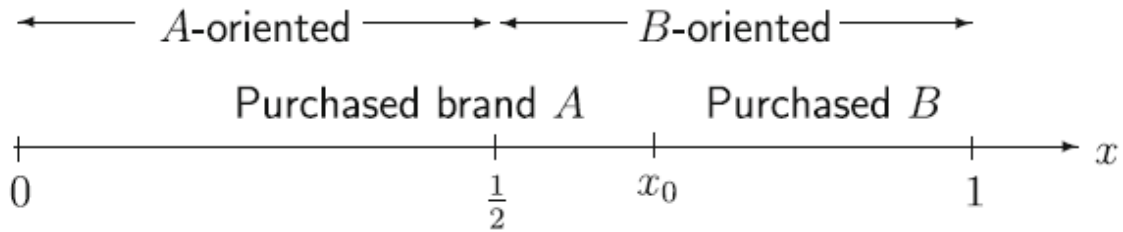


Figure 1 Characterization of purchase history

Consumers bear an exogenous cost σ when switching from one brand to another. The utility of a consumer indexed by x with a purchase history of brand $h(x) \in \{A, B\}$ is defined by

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

The first and third rows in Eq. 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, which is assumed to be sufficiently large so as to guarantee complete market coverage. The parameter $\tau > 0$ is the "transportation cost" parameter. A low value of τ will be interpreted as intense brand competition. The brand switching cost σ captures, 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. Formally, $h(x) = A$ for all $x \leq x_0$ whereas $h(x) = B$ for all $x > x_0$. With no loss of generality, we assume that $x_0 > 0.5$ which we take to mean that firm A is dominant. Throughout the present duopoly study we make the simple interpretation that a firm is dominant if it has a market share exceeding 50%.⁵ Figure 1 illustrates how the history of purchases relates to current brand preferences, as defined by Eq. 1.

We now classify purchase history as follows.

Definition 1 We say that the purchase history x_0 exhibits weak dominance if $0.5 < x < \bar{x} \stackrel{\text{def}}{=} (3\tau - \sigma)/(4\tau)$ and strong dominance if $x \geq \bar{x}$.

Figure 2 illustrates an equilibrium allocation of consumers under weak dominance. The left segment in Fig. 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 attracted by firm B at its poaching price q_B . The third range of consumers are those who switch

⁵ Note that the legal characterization of market dominance, for example in European competition law, does not necessarily refer only to market share.

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 .

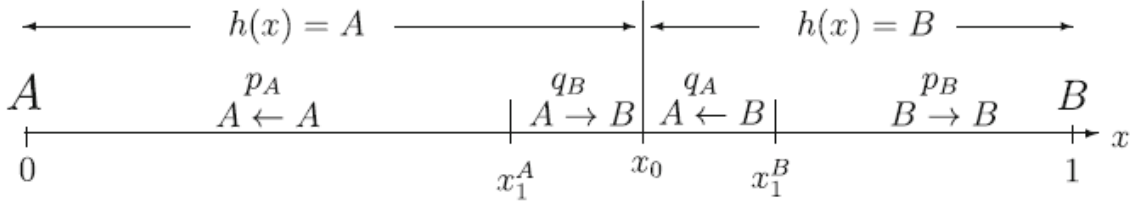


Figure 2 Consumer allocation between horizontally-differentiated brands under weak dominance

Note: Arrows indicate consumers' choice in each segment.

In contrast to Fig. 2, Fig. 3 illustrates this configuration under strong dominance. Strong dominance eliminates the range of consumers indexed on the interval $[x_0, x_1^B]$ in Fig. 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 , hence to attract consumers with low preference for brand A .

3.1 Weak dominance

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 $\beta - p_A - \tau x_1^A = \beta - q_B - \tau(1 - x_1^A) - \sigma$. 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 $\beta - p_B - \tau(1 - x_1^B) = \beta - q_A - \tau x_1^B - \sigma$. Therefore,

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

define a new allocation of consumers between the brands as illustrated in Fig. 2. In view of Fig. 2, the profit functions of firms A and B are defined by

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

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

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

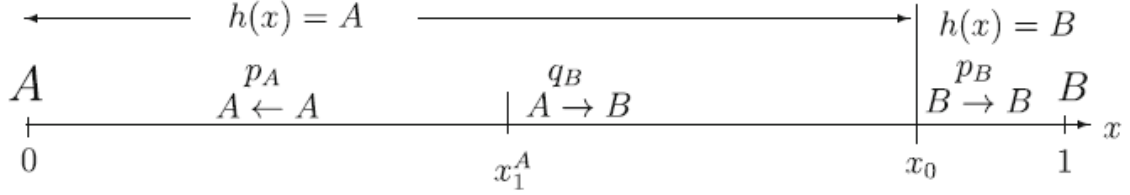


Figure 3 Consumer allocation between horizontally-differentiated brands under strong dominance

and the equilibrium poaching prices

$$q_A = c + \frac{\tau(3 - 4x_0) - \sigma}{3} \quad \text{and} \quad q_B = c + \frac{\tau(4x_0 - 1) - \sigma}{3}. \quad (5)$$

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

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

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

In view of Fig. 2, the number of switching consumers is $x_1^B - x_1^A = (\tau - \sigma)/(3\tau)$. It follows that $x_1^B - x_1^A > 0$ if and only if $\tau > \sigma$. This means that poaching is not profitable if $\sigma > \tau$. Therefore,

Result 1 For sufficiently high switching costs ($\sigma > \tau$) firms will not find it profitable to engage in history-based pricing.

In what follows, in order to induce some consumers to switch brands we make the following assumption, which guarantees that $0 < x_1^A < x_1^B < 1$, see Fig. 2.

Assumption 1 *The switching cost is lower than the transportation cost parameter. Formally, $\sigma < \tau$.*

We now compute the equilibrium market shares of firms A and B . From Eq. 6, in view of Fig. 2, the market share of the dominant firm is

$$m_1^A = x_1^A + (x_1^B - x_0) = \frac{2 - x_0}{3} < x_0. \quad (7)$$

Consequently, with history-based price discrimination, the market shares of the dominant firm decreases. The market share of the small firm is

$$m_1^B = 1 - x_1^B + x_0 - x_1^A = \frac{1 + x_0}{3} > 1 - x_0. \quad (8)$$

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 Eq. 4). The dominant firm loses market share. In this respect, history-based price discrimination does not by itself induce persistent dominance unless it is combined with some additional sufficiently strong strategic advantages.

3.2 Strong dominance

In Section 3.1 we focused on inherited weak dominance. We will now shift our attention to the configuration with strong dominance as characterized in Definition 1. This would eliminate the range of consumers indexed on the interval $[x_0, x_1^B]$ in Fig. 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 . Fig. 3 illustrates this configuration.

To compute the equilibrium prices supporting the configuration illustrated in Fig. 3, we set firm A 's poaching price to equal marginal cost, $q_A = c$. Comparing Fig. 3 with Fig. 2 reveals that now $x^B = x_0$. Substituting $q_A = c$ and $x^B = x_0$ into Eq. 2, firm B 's best reply is to set a loyalty price of $p_B = c + \tau(2x_0 - 1) + \sigma$. Since consumers are segmented by their purchase histories, the prices p_A and q_B remain unchanged. Altogether,

$$\begin{aligned}
p_A &= c + \frac{\tau(2x_0 + 1) + \sigma}{3}, & q_A &= c, \\
p_B &= c + \tau(2x_0 - 1) + \sigma, & \text{and} \\
q_B &= c + \frac{\tau(4x_0 - 1) - \sigma}{3}. & & (9)
\end{aligned}$$

To prove that the prices (9) indeed constitute a Nash equilibrium we must demonstrate that firm B cannot enhance its profit by raising its loyalty price p_B . We substitute p_A , q_A , and q_B from Eq. 9 into Eq. 3 to obtain

$$\left. \frac{\partial \pi_B}{\partial p_B} \right|_{(9)} = -\frac{4x_0\tau + \sigma - 3\tau}{2\tau} < 0 \quad \text{if and only if} \quad x_0 > \frac{3\tau - \sigma}{4\tau},$$

which holds by Definition 1 for the case of strong dominance. In view of Fig. 3, the number of switching consumers is $x_0 - x_1^A = [\tau(4x_0 - 1) - \sigma]/6\tau$. The resulting market shares are

$$\begin{aligned}
m_1^A &= x_1^A = \frac{\tau(2x_0 + 1) + \sigma}{6\tau} < x_0 \quad \text{and} \\
m_1^B &= 1 - m_1^A = \frac{\tau(5 - 2x_0) - \sigma}{6\tau} > 1 - x_0. & (10)
\end{aligned}$$

From Eq. 10 we can draw the conclusion that the market share of the dominant firm is eroded under history-based pricing. Thus, this feature holds true with inherited histories of strong dominance as well as weak dominance.

4 UNIFORM PRICING

In this section we focus on competition with uniform pricing. Figure 4 below illustrates the market shares when firms compete in uniform prices. Comparing Fig. 4 with Fig. 2 reveals that in the absence of price discrimination consumer switching may occur in one direction only. More precisely, the small firm B may gain some consumers from the dominant firm, but not the other way around. We now characterize this equilibrium.

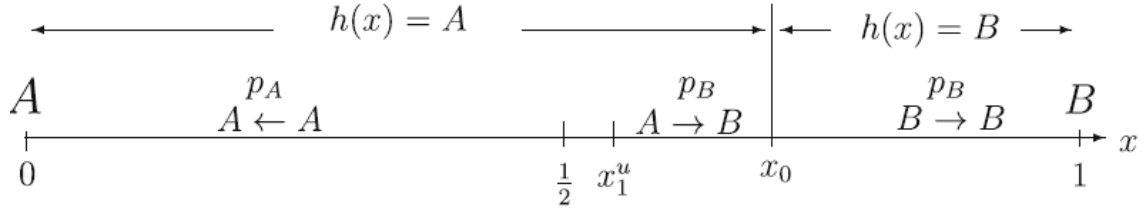


Figure 4 Consumer allocation between horizontally-differentiated brands under uniform pricing

In view of Fig. 4, 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

$$U(x) \stackrel{\text{def}}{=} \begin{cases} \beta - p_A - \tau x & \text{if } h(x) = A \text{ and continues to buy brand } A \\ \beta - p_B - \tau(1 - x) - \sigma & \text{if } h(x) = A \text{ and now switches to brand } B \\ \beta - p_B - \tau(1 - x) & \text{if } h(x) = B \text{ and continues to buy brand } B. \end{cases} \quad (11)$$

Under uniform pricing, a consumer x_1^u who is indifferent between being loyal to brand A and switching to brand B is determined by $\beta - p_A - \tau x_1^u = \beta - p_B - \tau(1 - x_1^u) - \sigma$. Hence, $x_1^u = (p_B - p_A + \sigma + \tau)/(2\tau)$. Firm A chooses a uniform price p_A to maximize $\pi_A = (p_A - c) x_1^u$. Similarly, firm B chooses a uniform price p_B to maximize $\pi_B = (p_B - c)(1 - x_1^u)$. The unique Nash–Bertrand equilibrium in prices and firm A 's market share are given by

$$p_A^u = c + \tau + \frac{\sigma}{3}, \quad p_B^u = c + \tau - \frac{\sigma}{3}, \quad \text{and} \quad x_1^u = \frac{1}{2} + \frac{\sigma}{6\tau} > \frac{1}{2}, \quad (12)$$

where superscript “ u ” indicates uniform pricing. From Eq. 12 we can directly observe that with uniform prices the inherited dominance (captured by x_0) has no effect on the price equilibrium. 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.

To investigate how different pricing methods affect the degree of market dominance we compare firm A 's market share under uniform pricing (12) with A 's market share under history-based pricing (7) with weak dominance. This comparison yields

$$x_1^u - m_1^A = (1 - x_0)/3 > 0, \text{ which implies the following}^6 \text{ result.}^6$$

Result 2 *The equilibrium market share of the firm with inherited market dominance is always larger under uniform pricing than under history-based pricing.*

From Result 2 we can draw the conclusion that uniform pricing is more useful than history-based pricing for the dominant firm as an instrument to defend dominance.

Another dimension of evaluation is to compare the equilibrium prices under uniform and history-based price discrimination. Comparing Eq. 12 with Eqs. 4 and 5, we find that

$$\begin{aligned} p_A^u - p_A &= 2\tau(1 - x_0)/3 > 0, p_A^u - q_A = 2(2x_0\tau + \sigma)/3 > 0, p_B^u - p_B = \\ &4\tau(1 - x_0)/3 > 0. \text{ Also, } p_B^u - p_B = \\ &= 2(x_0\tau - \sigma)/3 > 0 \text{ if } \sigma/\tau < x_0 < (3\tau - \sigma)/(4\tau). \end{aligned}$$

Based on these price comparisons we can conclude that competition with history-based pricing generates lower prices than competition with uniform pricing with the potential exception of the loyalty price p_B charged by the small firm. The small firm charges a higher price p_B with history-based pricing than with uniform pricing if the degree of inherited dominance is very weak, that is, if x_0 is close to 0.5, and if the switching costs are large, that is, σ is sufficiently close to τ .

The general feature that price discrimination intensifies competition compared with uniform pricing is a well-established result in the literature, see for example Thisse and Vives (1988) or Chen (1997). In this respect our contribution is fairly marginal as we establish this feature to hold in most cases also with an asymmetric industry with an inherited market dominance rather than a symmetric industry. We nevertheless want to draw attention to our result that uniform pricing is more powerful than history-based

⁶ The identical conclusion for inherited strong dominance can be reached in a straightforward way.

pricing as an instrument for a dominant firm to defend its inherited market share advantage, a characterization which has not been emphasized in the existing literature. Overall, in the present analysis the main purpose of this price comparison is to facilitate the detailed welfare analysis given in the next section.

5 WELFARE ANALYSIS

So far we have explored the effects of history-based price discrimination on prices and market shares. We next investigate the welfare consequences of history-based price discrimination in an asymmetric duopoly. Such an investigation is very important as a basis for a policy maker, operating with a well-defined welfare objective, to formulate a policy towards history-based price discrimination exercised by a dominant firm.

5.1 Comparing uniform pricing with history-based pricing under weak dominance

Consumer surplus under uniform pricing is

$$\begin{aligned}
 CS^u &= \int_0^{x_1^u} (\beta - p_A^u - \tau x) dx + \int_{x_1^u}^{x_0} [\beta - p_B^u - \tau(1-x) - \sigma] dx \\
 &\quad + \int_{x_0}^1 [\beta - p_B^u - \tau(1-x)] dx, \tag{13}
 \end{aligned}$$

where p_A^u , p_B^u , and x_1^u are given in Eq. 12. Similarly, consumer surplus under history-based price discrimination is

$$\begin{aligned}
 CS^d &= \int_0^{x_1^A} (\beta - p_A - \tau x) dx + \int_{x_1^A}^{x_0} [\beta - q_B - \tau(1-x) - \sigma] dx \\
 &\quad + \int_{x_0}^{x_1^B} [\beta - q_A - \tau x - \sigma] dx + \int_{x_1^B}^1 [\beta - p_B - \tau(1-x)] dx, \tag{14}
 \end{aligned}$$

where p_A , q_A , p_B , q_B , x_1^A , and x_1^B are given in Eqs. 4–6. Subtracting Eq. 13 from Eq. 14, our calculations show that

$$CS^d - CS^u = -\frac{\tau^2(52x_0^2 - 52x_0 - 1) + 2\sigma\tau(17 - 18x_0) - \sigma^2}{36\tau}. \tag{15}$$

Let $0 \leq s \leq 1$. Substituting $\sigma = s\tau$ into Eq. 15,

$$CS^d - CS^u = -\frac{\tau[s^2 + 2s(18x_0 - 17) - 52x_0^2 + 52x_0 + 1]}{36} > 0 \quad (16)$$

if

$$s < 17 - 18x_0 - 2\sqrt{2}\sqrt{47x_0^2 - 83x_0 + 36} \quad \text{for} \quad \frac{1}{2} < x_0 < \frac{3}{4} - \frac{s}{4}. \quad (17)$$

Figure 5 illustrates the sign of $CS^d - CS^u$ in the (x_0, s) space.

Result 3 *Under weak dominance, consumer surplus is higher with history-based price discrimination than with uniform pricing if and only if condition (17) holds.*

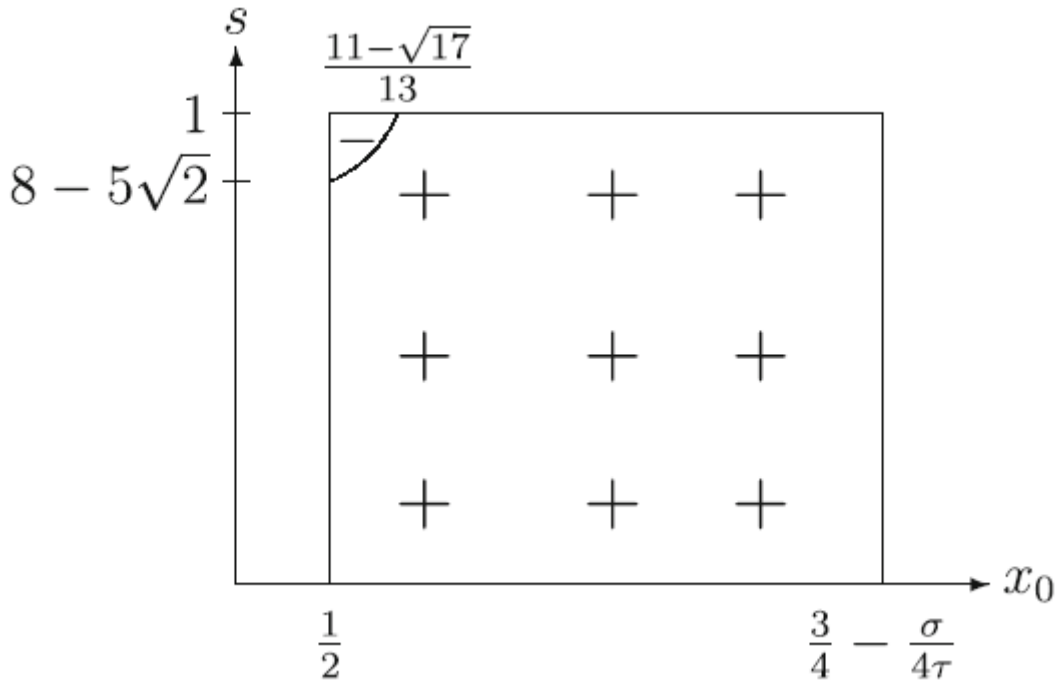


Figure 5 Differences in consumer surplus under weak dominance

In view of Fig. 5, history-based price discrimination benefits consumers for most values of σ and x_0 . However, for sufficiently high switching cost σ ($\sigma > 0.93\tau$) combined with a sufficiently low degree of inherited dominance x_0 ($0.5 < x_0 < 0.53$) consumers are worse off under history-based price discrimination. Consequently, unless faced with the particular combination of sufficiently high switching costs ($\sigma > 0.93\tau$) and a sufficiently

low degree of inherited dominance ($0.5 < x_0 < 0.53$) a competition authority with consumer welfare as its objective should not oppose to history-based price discrimination.

As our comparison of history-based prices and uniform prices in the previous section showed, history-based price discrimination tends to yield lower prices than uniform pricing and therefore consumers benefit from history-based pricing for most parameter combinations. However, we also pointed out that the small firm charges a higher price p_B with history-based pricing than with uniform pricing if the degree of inherited dominance is very weak, that is, if x_0 is close to 0.5, and if the switching costs are large (σ is sufficiently close to τ). Under those circumstances when condition (17) fails to hold, the loyalty price charged by the small firm under history-based pricing is much higher than under uniform pricing, thereby making consumer surplus with uniform pricing exceed consumer surplus with history-based price discrimination.

We now calculate the equilibrium profit of each firm under uniform pricing.

Substituting Eq. 12 into the profit under uniform pricing yields

$$\pi_A^u = \frac{(3\tau + \sigma)^2}{18\tau} \quad \text{and} \quad \pi_B^u = \frac{(3\tau - \sigma)^2}{18\tau}. \quad (18)$$

Therefore, under uniform pricing, the profit advantage of the dominant firm is $\pi_A^u - \pi_B^u = 2\sigma/3 > 0$.

Next, we calculate the equilibrium profit of each firm under history-based pricing. Substituting Eqs. 4–6 into Eq. 3 yields

$$\begin{aligned} \pi_A^d &= \frac{5\tau^2(2x_0^2 - 2x_0 + 1) + 2\sigma\tau(3x_0 - 1) + \sigma^2}{9\tau} \quad \text{and} \\ \pi_B^d &= \frac{5\tau^2(2x_0^2 - 2x_0 + 1) + 2\sigma\tau(2 - 3x_0) + \sigma^2}{9\tau}. \end{aligned} \quad (19)$$

Therefore, under history-based pricing, the profit advantage of the dominant firm is

$\pi_A^d - \pi_B^d = 2\sigma(2x_0 - 1)/3 < 2\sigma/3$. Hence, the profit advantage of the dominant firm

is smaller under history-based pricing compared with uniform pricing. Furthermore, from Eqs. 18 and 19, we argue that aggregate industry profit is always higher under uniform pricing, formally

$$(\pi_A^d + \pi_B^d) - (\pi_A^u + \pi_B^u) = \frac{\tau^2(20x_0^2 - 20x_0 + 1) + 2\sigma\tau + \sigma^2}{9\tau} < 0. \quad (20)$$

Consequently, firms have a mutual interest to compete in uniform prices rather than in prices based on consumers' purchase histories. We now prove the inequality (20). Using the definition of weak dominance given in Definition 1, substituting the lowest ($x_0 = 0.5$) and the highest ($x_0 = (3\tau - \sigma)/(4\tau)$) values of x_0 into Eq. 20 yields $(\sigma^2 + 2\sigma\tau - 4\tau^2)/(9\tau) < 0$ and $(9\sigma^2 - 2\sigma\tau - 11\tau^2)/(9\tau) < 0$, respectively. Also, differentiating Eq. 20 with respect to x_0 yields $20\tau(2x_0 - 1)/9 > 0$ implying that Eq. 20 increases monotonically with x_0 at the relevant range and therefore does not change sign.

A detailed analysis of firm-specific profit reveals that the dominant firm is always better off under uniform pricing than under history-based pricing. Formally,

$$\pi_A^d - \pi_A^u = \frac{20x_0^2\tau^2 + 4x_0\tau(3\sigma - 5\tau) + \sigma^2 - 10\sigma\tau + \tau^2}{18\tau} < 0. \quad (21)$$

To prove the above inequality, evaluating Eq. 21 at $x_0 = 0.5$ (lowest value) yields $(\sigma^2 - 4\sigma\tau - 4\tau^2)/(18\tau) < 0$. Evaluating Eq. 21 at $x_0 = 0.75$ (highest value) yields $(4\sigma^2 - 4\sigma\tau - 11\tau^2)/(72\tau) < 0$. Differentiating Eq. 21 with respect to x_0 yields $2(10x_0\tau + 3\sigma - 5\tau)/9 > 0$, implying that does not change sign in the relevant range of x_0 .

The relative magnitudes of the small firm's profits associated with uniform pricing and history-based pricing varies with the parameters of the model. Formally, we compute

$$\pi_B^d - \pi_B^u = \frac{20x_0^2\tau^2 - 4x_0\tau(3\sigma + 5\tau) + \sigma^2 + 14\sigma\tau + \tau^2}{18\tau}. \quad (22)$$

The following result shows that firm B benefits from history-based price discrimination if and only if the switching costs are sufficiently high. Specifically,

Result 4 *The smaller firm (firm B) benefits from history-based price discrimination if and only if $\sigma > \hat{\sigma} \stackrel{\text{def}}{=} \tau(4\sqrt{x_0^2 - 4x_0 + 3} + 6x_0 - 7)$.*

We now prove Result 4. Differentiating Eq. 22 with respect to the switching cost parameter σ obtains $[\sigma + (7 - 6x_0)]/(9\tau) > 0$. Evaluating Eq. 22 at $\sigma = 0$ (no switching costs), yields $\tau(20x_0^2 - 20x_0 + 1)/18 < 0$. Hence, Eq. 22 monotonically increases with σ starting with a negative value. Therefore, Eq. 22 is positive for, $\sigma > \hat{\sigma}$, where $\hat{\sigma}$, defined in Result 4, is the admissible switching cost at which the numerator in Eq. 22 is zero.

Note that Assumption 1 is satisfied because $\hat{\sigma} < \tau$ as long as $x_0 < 1$ (the dominant firm has less than 100% initial market share). Although Result 2 states that the smaller firm has a lower market share under history-based pricing compared with uniform pricing, Result 4 shows that it will still collect higher profit under history-based pricing if consumers bear sufficiently high switching costs. For switching costs lower than the threshold defined in Result 4 there is a potential for the dominant firm to exploit history-based price discrimination as a device to facilitate predation.

Under such circumstances, within the framework of our model, the only motivation for the dominant firm to adopt history-based pricing is to exclude the small firm from the market (because if fixed costs were assumed, reduced profit may cause firm B to exit the market). Thus, even though Result 3 implies that consumers typically benefit from history-based pricing our model nevertheless also raises concerns related to the potential of history-based pricing to serve as a device to facilitate exclusion.

As Result 4 makes clear, there are reasons for such concerns regarding potential exclusionary abuse when the switching costs are sufficiently low.

When evaluating the antitrust implications of price discrimination an influential recent approach, including, for example, Innes and Sexton (1994) and Karlinger and Motta (2007), seems to persistently emphasize the following trade-off. On the procompetitive side, for an oligopolistic industry operating within a given market structure, price discrimination intensifies competition. On the anticompetitive side, with price discrimination the dominant firm can induce exclusion more effectively 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 the implications of history-based price discrimination for competition and welfare are

perfectly consistent with this view as long as the switching costs are low. It is interesting to differentiate Result 4 from the conclusions reached in Gehrig et al. (2011), where it is shown that the entry decision of a firm with no access to information about consumers' purchase histories is invariant to whether the incumbent implements history-based pricing or uniform pricing. Thus, in Gehrig et al. (2011) the potential abuse of consumers imposed by history-based pricing is exploitation, not exclusion. Consequently, we can draw the general conclusion that the potential antitrust threats created by history-based pricing are sensitive to whether the small firm has access to information about consumers' purchase histories or not.

With the exception of sufficiently high switching costs ($\sigma > 0.93\tau$) combined with a sufficiently low degree of inherited dominance ($0.5 < x_0 < 0.53$), history-based prices generate a distributional conflict between firms and consumers. We next evaluate whether the benefits to consumers associated with history-based pricing exceed the firms' loss of profits.

We define social welfare as the sum of consumer surplus and firms' profits, $W = CS + \pi_A + \pi_B$. Under uniform pricing, social welfare is given by

$$W^u = \frac{5\sigma^2 - 9\tau^2 + 18\tau(2\beta + \sigma - 2c - 2x_0\sigma)}{36\tau}. \quad (23)$$

Social welfare under history-based pricing is

$$W^d = \frac{2\tau^2(7x_0^2 - 7x_0 - 1) + 2\tau(9\beta - 9c - 2\sigma) + 5\sigma^2}{18\tau}. \quad (24)$$

Subtracting Eq. 23 from Eq. 24 yields

$$W^d - W^u = \frac{\tau^2(28x_0^2 - 28x_0 + 5) + 2\sigma\tau(18x_0 - 13) + 5\sigma^2}{36\tau}. \quad (25)$$

It can be easily established that Eq. 25 is strictly increasing with x_0 . Furthermore, $W^d(\bar{x}_0) - W^u(\bar{x}_0) = -(9\sigma^2 + 10\sigma\tau - \tau^2)/(144\tau) < 0$ for $\bar{x}_0 = (3\tau - \sigma)/(4\tau)$, which is the upper bound on x_0 by Definition 1.

Result 5 *Social welfare is higher under uniform pricing compared with history-based pricing.*

With Hotelling competition, price changes generate a redistribution of surplus between consumers and producers, whereas aggregate switching costs and transportation costs are “real” deadweight losses to the economy. In order to understand the sources behind the total welfare gains associated with uniform pricing it is therefore valuable to highlight the effects of history-based pricing on aggregate switching costs and transportation costs. With history-based pricing, Eq. 6 implies that the number of switching consumers is $(x_0 - x_1^A) + (x_1^B - x_0) = (\tau - \sigma)/(3\tau)$, whereas $x_1^u = x_0 - (\sigma - 3\tau)/(6\tau)$. The difference between the two is $(5\tau - \sigma - 6x_0\tau)/(6\tau) \geq (\sigma + \tau)/2 > 0$, after we substitute the highest possible value of x_0 from Definition 1 of weak dominance. Hence, the number of switching consumers with history-based pricing exceeds that associated with uniform pricing for an inherited history with weak dominance. Therefore, history-based price discrimination generates higher aggregate switching costs than uniform pricing. Furthermore, with uniform pricing the switching also decreases the degree of preference mismatch, leading to lower aggregate transportation costs as some consumers located to the right of 0.5 switch to B . With history-based pricing the effect of switching on aggregate transportation costs is not a priori clear, because the consumers switching from A to B face reduced transportation costs, whereas those switching from B to A face increased transportation costs. Our total welfare comparison establishes analytically that uniform pricing induces lower aggregate switching costs and transportation costs than history-based price discrimination.

It is valuable to compare our welfare conclusions reached in Results 3 and 4 with those of Esteves (2010). Like Esteves (2010) we find that consumers typically benefit from history-based pricing compared with uniform pricing. However, in contrast to Result 4, Esteves (2010) reaches the conclusion that history-based pricing promotes social welfare. A possible explanation behind this difference is that the model in Esteves (2010) captures a symmetric two-period duopoly model, where firms apply mixed pricing strategies in the first period. In contrast, we focus on an inherently asymmetric one-period model with a price equilibrium in pure strategies.

Furthermore, we also incorporate switching costs. But, the switching costs alone are not responsible for the different conclusions regarding social welfare. This can be seen by substituting $\sigma = 0$ into Eq. 25. Nevertheless, switching costs play an important role in

our model. As Result 4 emphasizes, the significance of the potential concern for exclusionary abuse is critically linked to the magnitude of the switching costs.

In light of our focus on an industry with inherited asymmetric market shares as an exogenous feature, our welfare conclusions apply primarily to established markets characterized by minor concerns for new customers. In contrast, the analysis of Esteves (2010) seems more relevant in growing markets with large shares of new customers. Overall, the comparison of our welfare conclusions with those of Esteves (2010) emphasize that the welfare implications of history-based price discrimination depend on the maturity of the underlying markets.

5.2 Comparing uniform pricing with history-based pricing under strong dominance

In this subsection we explore the welfare implications of history-based pricing for the configuration of strong dominance in a way analogous to the analysis undertaken for weak dominance in the previous subsection. Under strong dominance, consumer surplus with history-based pricing is

$$CS^d = \int_0^{x_1^A} (\beta - p_A - \tau x) dx + \int_{x_1^A}^{x_0} [\beta - q_B - \tau(1-x) - \sigma] dx + \int_{x_0}^1 [\beta - p_B - \tau(1-x)] dx, \quad (26)$$

where p_A , p_B , q_B , and x_1^A are given in Eqs. 9 and 10.

Subtracting Eq. 13 from Eq. 26, we find

$$CS^d - CS^u = \frac{(1-x_0)[\tau(16-7x_0) - 13\sigma]}{9} > 0 \quad \text{if and only if} \\ \sigma < \frac{\tau(16-7x_0)}{13} \quad \text{with} \quad \frac{3}{4} - \frac{\sigma}{4\tau} < x_0 < 1. \quad (27)$$

Therefore,

Result 6 *Under strong dominance, consumer surplus is lower with history-based price discrimination than with uniform pricing if switching costs are sufficiently high, more precisely, if $\sigma > \tau(16-7x_0)/13$.*

Comparing Result 6 with Result 3 we can conclude that the implications of history-based price discrimination are sensitive to whether there is strong or weak dominance. In both

cases, consumers benefit from history-based pricing unless the switching costs exceed a specified threshold, which is much higher with weak dominance. With weak dominance consumer surplus with uniform pricing exceeds that with history-based pricing for the combination of sufficiently high switching costs ($\sigma > 0.93\tau$) and a sufficiently low degree of inherited dominance ($0.5 < x_0 < 0.53$), as the discussion after Result 3 makes clear. According to Result 6 the switching cost threshold required for uniform pricing to benefit consumers is lower with inherited strong dominance than with weak dominance. The dominant firm does not engage in poaching under strong dominance and therefore competes less aggressively for the customers with a relationship with the small firm. This qualitative difference to the configuration with weak dominance is the reason for the discontinuity in the threshold values of the switching costs, below which consumers benefit from history-based pricing.

Using Eqs. 9 and 10, the equilibrium profit of each firm with history-based pricing under strong dominance is

$$\pi_A^d = \frac{[\tau(2x_0 + 1) + \sigma]^2}{18\tau} \quad \text{and} \quad \pi_B^d = \frac{\tau^2(46x_0 - 20x_0^2 - 17) + 2\sigma\tau(10 - 13x_0) + \sigma^2}{18\tau}. \quad (28)$$

Comparing total industry profit under history-based price discrimination (28) with industry profit under uniform pricing (18) yields

$$\begin{aligned} & (\pi_A^d + \pi_B^d) - (\pi_A^u + \pi_B^u) \\ &= \frac{(1 - x_0)[\tau(8x_0 - 17) + 11\sigma]}{9} > 0 \quad \text{if and only if} \quad \sigma > \frac{\tau(17 - 8x_0)}{11}. \end{aligned} \quad (29)$$

Contrary to the case with weak dominance (20), we now find that the adoption of history-based price discrimination could be profit enhancing. This happens for sufficiently high switching costs.

Analogously to the configuration with weak dominance, it can be shown that the dominant firm is always better off under uniform pricing than under history-based pricing. Similarly, the small firm benefits from history-based price discrimination if and only if the switching costs are sufficiently high. Therefore, as with weak dominance, under strong dominance there is a potential for the dominant firm to exploit history-

based price discrimination as a device to facilitate predation if the switching costs are sufficiently low.

Finally, similar to Eq. 25, the difference in social welfare is

$$W^d - W^u = -\frac{(1 - x_0)[\tau(1 - x_0) + 2\sigma]}{9} < 0. \quad (30)$$

Therefore,

Result 7 *Social welfare is higher under uniform pricing compared with history-based pricing.*

Overall, the result that uniform pricing promotes total welfare is a robust conclusion, which holds true independently of whether the industry inherits weak or strong dominance. Under strong dominance with history-based pricing the number of switching consumers is $(x_0 - x_1^A)$, whereas this number is $(x_0 - x_1^U)$ under uniform pricing. Based on Eqs. 10 and 12 we can directly draw the conclusion that history-based price discrimination generates higher aggregate switching costs than uniform pricing. History-based pricing also leads to higher aggregate transportation costs with an inherited history of strong dominance.

6 CONCLUSION

We design an asymmetric duopoly model with inherited market dominance where both firms, the dominant firm and the small firm, can price discriminate between consumers based on their purchase history. We find that uniform pricing is more powerful than history-based pricing as an instrument for the dominant firm to defend its market share advantage. We show that uniform pricing tends to soften price competition, leading to higher industry profits under uniform pricing than under history-based price discrimination.⁷ With weak dominance we establish that consumers benefit from history-based price discrimination unless the switching cost is sufficiently high and the inherited degree of dominance is sufficiently weak.

Consequently, unless the switching costs are sufficiently high and the inherited degree of dominance is sufficiently weak a ban on history-based price discrimination would introduce a distributional conflict between consumers and producers with the consumers as losers. Finally, we establish that the gains to industry profits associated with uniform pricing exceed the associated losses to consumers.

Our analysis of the asymmetric duopoly model implies that the use of history-based price discrimination typically tends to intensify competition and thereby promote consumer welfare. In light of this conclusion our analysis of consumer surplus tends to give no support for policies to ban history-based price discrimination.

Formally, our analysis has been restricted to an asymmetric Hotelling model with the special feature of inelastic demand at the industry level. The conclusion that history-based pricing tends to intensify competition and promote consumer welfare 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 promoting consumer welfare.

However, at the same time our analysis reaches the unambiguous conclusion that uniform pricing promotes total welfare. This means that concerns for industry profits will eventually shift the policy recommendation in favor of banning history-based price discrimination. To the extent increased industry profits facilitate increased investments

⁷ Uniform pricing always softens competition with an inherited history of weak dominance. This holds true also with strong dominance as long as the switching cost is not too high.

and innovation such concerns could potentially even enhance future consumer surplus. Our model could be enriched by incorporating such dynamic considerations.

Our analysis implies that there is no simple and universal antitrust policy to deal with history-based pricing. As far as the welfare implications are concerned, our present analysis establishes that consumers tend to benefit from history-based price discrimination if also the small firm can apply behavior-based pricing, whereas Gehrig et al. (2011) demonstrate that this pricing practice reduces consumer surplus if the dominant firm has exclusive access to price discrimination. Nevertheless, from the point of view of topical European competition policy related to the application of Article 102 in the Treaty of Lisbon ⁸ our analysis has a very robust implication. Our analysis offers strong support for an effects-based approach to the evaluation of history-based price discrimination as a business practice, which could potentially qualify as abusive conduct if applied by a dominant firm. In this regard the analysis provides strong support in favor of the effects-based approach suggested by Gual et al. (2006) to guide European antitrust policy.

Our analysis has focused on an industry with inherited asymmetric market shares as an exogenous feature. ⁹ There could be many different sources behind the inherited asymmetry. The inherited asymmetric market shares could, for example, be based on historically segmented markets with local monopolies of unequal size. Suppose then that these markets are integrated in a way which had not been anticipated. Such a configuration fits perfectly well into our model. Our analysis gives a precise characterization of how history-based pricing affects competition in the integrated market compared with uniform prices. Likewise, our analysis gives a detailed answer to the following question: How does history-based competition affect firms of small countries relative to those of large countries if this type of price discrimination is allowed after integration? Despite these justifications for the inherited asymmetric market shares as an exogenous feature our model suffers from the weakness that it ignores competition new consumers. Clearly, access to history-based price discrimination alters the nature of competition for new customers, and this feature would have welfare implications for the welfare evaluations of history-based price discrimination if our model were extended to a two-period framework. Some of the relevant considerations in this respect were

⁸ See, <http://ec.europa.eu/competition/information/treaty.html>.

⁹ This feature we share with, for example, Shaffer and Zhang (2000).

presented when we compared results in Section 5.1 with those attained in the symmetric two-period model of Esteves (2010).

Throughout this study we have analyzed the implications of history-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, in particular, characterize the market shares towards which the process would converge.

¹⁰ Of course, such an analysis could quickly become extremely complicated if the firms are able to maintain information on customer histories consisting of several periods.

¹¹Our 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.

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 pre-mia. ¹² 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. Compared to our model this approach exhibits a completely divergent intertemporal structure of the price equilibrium. In their recent analysis of intertemporal pricing for firms able to commit to future prices, Chen and Percy (2010) demonstrate that consumer loyalty is rewarded if the persistence of consumer preferences is low, whereas enticing brand switching occurs if the persistence of consumer preferences is high.

¹⁰ The dynamics of price equilibria and market shares has have been explored in Chen (2008) and Begg and Klemperer (1992). They have not, however, conducted a welfare analysis to fully explore the antitrust implications.

¹¹ A complete implementation of history-based pricing during T periods would split the market into 2^{T+1} segments, each with its own history-contingent price.

¹² Caminal and Clatici (2007) have subsequently developed that analysis further.

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