

PERSONALIZED PRICING VERSUS HISTORY-BASED PRICING: IMPLICATIONS FOR PRIVACY POLICY*

Topi Miettinen**

Rune Stenbacka***

12 March 2015

We compare personalized and history-based pricing and show that personalized pricing harms consumer surplus and total welfare when evaluated over a two-period horizon. The horizon is important because, with a one-period horizon, the pricing system has no effect on total welfare, and personalized pricing introduces a distributional conflict between firms and consumers. When customer relationships are endogenous, consumers benefit from privacy protection without sacrifice of industry profits. The key mechanism is that the discounted two-period profits are invariant to whether personalized or history-based pricing is applied because higher period-2 profits with personalized pricing are offset by lower period-1 profits.

KEYWORDS: *personalized pricing, history-based pricing, customer recognition, price discrimination, privacy, switching cost, information acquisition, price competition, horizontal product differentiation*

JEL: L40, L13, D43

*We are grateful to Oz Shy for valuable comments.

** Hanken School of Economics, P.O. Box 479, 00101 Helsinki, Finland. E-mail Topi.Miettinen@hanken.fi

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

1. Introduction

The progress of information technology, such as commercial internet applications with big data, has to an increasing extent facilitated the adoption of various degrees of personalized pricing by firms. This development has initiated a topical debate about the privacy issues regarding the exploitation of customer-specific information as a basis for advertising and pricing. As emphasized by FTC (2012) and Brill (2013), for instance, there are important interconnections between privacy policy and competition policy.

In this study we analyze the effects of privacy protection on consumer welfare and industry profits by comparing personalized pricing with history-based pricing within a two-period model with switching costs. With personalized pricing firms are able to acquire customer-specific information regarding the preferences of the customers they have acquired in period 1, whereas with history-based pricing firms are able to condition period-2 prices only on consumer history, i.e. whether the consumer has an established customer relationship with the firm itself or with its rival¹. As an analysis of privacy policy this builds on the view that pricing conditional on customer history alone is not a violation of privacy protection, but that the crucial issue of privacy protection is whether personalized pricing is allowed. The analysis is conducted in a two-period horizon so that we can distinguish the effects of personalized pricing on competition at the stage when customer relationships are formed from those at the stage when firms exploit established customer relationships.

We analytically establish that the price equilibrium in an ex ante symmetric duopoly with switching costs is characterized by the feature that the period-1 competition for the formation of customer relationships is precisely so fierce as to neutralize the incumbency rents which can be made from customers locked-in by the switching costs in period 2 irrespectively of whether firms apply personalized pricing or history-based pricing. In addition, we demonstrate that the discounted two-period profits are invariant to whether personalized pricing or history-based pricing is applied when evaluated over a two-period horizon. Moreover, the personalized pricing system leads to higher price fluctuations between periods.

¹ Chen (1997) and Fudenberg and Tirole (2000) developed path-breaking models for the analysis of history-based or behavior-based pricing. Fudenberg and Villas-Boas (2007) and Esteves (2009) present surveys on the literature focusing on history-based or behavior-based pricing.

Conducting the analysis with a two-period horizon with endogenous market segmentation has interesting implications for privacy policy. We establish analytically that the application of personalized pricing harms consumer welfare and total welfare compared with history-based pricing. Furthermore, with an endogenous distribution of customer relationships the consumers benefit from privacy protection, but this benefit to consumers is realized without sacrifice in terms of industry profits, since the discounted two-period profits are invariant to whether personalized pricing or history-based pricing is applied. In contrast, with a static analysis focusing on exogenously inherited market segments there is a distributional conflict between firms and consumers.

The beneficial effect of privacy protection on consumer surplus is neither due to lower total switching costs nor to a better initial allocation of clientele. The gains from privacy protection to consumer are generated by the fact that personalized pricing promotes inefficient switching, i.e. switching from a preferred to a less-preferred brand, at the expense of efficient switching, i.e. switching in the opposite direction. The mechanism behind this feature is that personalized pricing leads to higher markups targeted to high-value customers and lower markups to the low-value customers in the second period. Since the poaching offers cannot be conditioned on these intrinsic preference characteristics, the second-period consumer surplus is lower under personalized pricing than under history-based pricing.

Seminal contributions to the literature focusing on the economic aspects of privacy policy include Posner (1978, 1981) and Stigler (1980). These researchers developed the “Chicago School” view, according to which there is no justification for government policies to protect consumer privacy because privacy protection creates inefficiencies. A number of subsequent studies, for example Hermalin and Katz (2006) and Taylor (2004), have challenged this view. Taylor and Wagman (2014) present a survey of the recent literature focusing on the effects of restrictions regarding the exploitation of customer-specific information for consumer and producer surplus. They characterize the winners and losers of privacy restrictions in oligopolistic industries and emphasize that the welfare effects of such restrictions are to a large extent industry-specific and sensitive to the prevailing nature of competition. There is also an extensive literature, summarized by Tucker (2012), focusing

specifically on how privacy concerns affect advertising markets. Our study does not focus on advertising markets.

Esteves (2010) has compared history-based pricing with uniform pricing in order to evaluate the effects of history-based on profits and welfare within the framework of a two-period model. Contrary to such an approach we present an analysis of personalized pricing compared with history-based pricing, therefore a comparison focusing precisely on the effects of privacy protection defined by whether personalized pricing is allowed or not.

Shy and Stenbacka (2014) present a static evaluation of the effects for profits and consumer welfare of different degrees of privacy protection in a static context, with inherited customer relationships as an exogenous feature. The present analysis is distinguished from Shy and Stenbacka (2014) along several dimensions, most importantly because it makes the inherited customer relationships endogenous. Of course, one could apply alternative mechanisms for information acquisition. For example, in Shy and Stenbacka (2013) the firms learn the preferences of their customers by investing a fixed amount². More sophisticated models, capturing that firms have access to imperfect tests for the determination of customer types are developed by Chen et al (2001), Liu and Serfes (2004) and Esteves (2014). However, these studies are not oriented towards an evaluation of personalized pricing from the perspective of privacy policy and they do not conduct comparisons of the regimes with personalized pricing and history-based pricing.

In our model firms keep the acquired customer-specific information as private information and consumers have access to no technology for “hiding” their generic preferences. Acquisti and Varian (2005) and Conitzer et al (2012) have explored models where consumers can either avoid being detected as past customers or avoid revealing their individual characteristics. Taylor (2004) and Casadesus-Masanell and Hervas-Drane (2015) have explored the strategic implications of options to firms of selling consumer-specific information in secondary markets.

² Shy and Stenbacka (2013) explores the effects of information exchange between competitors regarding customer preferences on investments in information acquisition within the framework of a static model. Other aspects of information exchange have been studied in a related context by Jentsch et al (2013).

Finally, it should be emphasized that our evaluation of privacy protection is restricted to aspects purely related to economic efficiency. Privacy protection could also be defended by reference to its intrinsic value associated with the respect for individual integrity typical for the western democracies, but such considerations are outside the scope of the present study.

The study proceeds as follows. Section 2 presents the two-period model. Section 3 analyzes the price equilibrium with history-based pricing, whereas Section 4 focuses on personalized pricing with recognition of consumer preferences. Section 5 presents the central welfare comparisons between history-based and personalized pricing and explores the implications for privacy policy. Finally, we finish our study with concluding comments in Section 6.

2. The Two-Period Model

Consider a duopolistic industry engaging in price competition over a two-period horizon. The competitors, firms A and B, produce differentiated goods in an industry where the market is represented by a Hotelling model on the unit interval. Firm A is located at $x=0$, whereas firm B is located at $x=1$. There are two types of consumers. A unit mass of consumers uniformly distributed on the unit interval are A-oriented (B-oriented) meaning that they hold a generic valuation v^H for variety A (B), whereas their valuation for variety B (A) is v^L with $v^H > v^L$. The difference $\Delta = v^H - v^L$ captures the high valuation premium in generic preference. Depending on orientation, each consumer has a strict generic preference for either A or B. Notice that there is a unit mass of consumers with each type of generic preference (A- and B-oriented).

Each consumer buys exactly one unit of the good (either A or B) in each period. Contingent on the inherited market segmentation, in period 2 each consumer either remains loyal to its period-1 supplier or switches to the competitor. We assume that each consumer faces a homogeneous switching cost $s > 0$. We let p_2^i denote the loyalty price firm i ($i=A,B$) charges a consumer with whom it has an established customer relationship, whereas q_2^i denotes the poaching price it charges a consumer belonging to the rival's inherited customer segment.

In line with the standard Hotelling model, consumers have idiosyncratic preferences, which are represented by their locations. These locations are uniformly distributed on the unit interval.

Faced with period-2 prices p_2^A and q_2^B an A -oriented consumer with an established customer relationship with firm A and located at x has a period-2 utility function ³

$$u_2^{A,A}(x) = \begin{cases} v^H - p_2^A - t x, & \text{if staying loyal to } A \\ v^L - q_2^B - t(1-x) - s, & \text{if switching to } B \end{cases}. \quad (1)$$

The utility function (1) captures linear transportation costs, where the transportation cost t is the differentiation parameter, which is inversely related to the intensity of competition. Further, an A -oriented consumer with an established customer relationship with firm B and facing prices p_2^B and q_2^A has the period-2 utility function

$$u_2^{A,B}(x) = \begin{cases} v^L - p_2^B - t(1-x), & \text{if staying loyal to } B \\ v^H - q_2^A - t x - s, & \text{if switching to } A \end{cases}. \quad (2)$$

Conditional on whether the inherited customer relationship is with firm A or firm B , the period-2 utility function for a B -oriented consumer is defined in a way analogous to (1) or (2).

We assume that all consumers are randomly relocated across periods⁴. Thus, the generic valuation v represents the persistent component associated with the consumer's preferences, whereas the location x captures the period-specific component of these preferences. For mobile phones, for instance, the persistent component of the preferences could focus on the operating system, whereas the period-specific component could focus on other characteristics like design, which tend to be model-specific and subject to frequent changes. The segment for premium cars could offer another example. The consumer might have a persistent preference for one particular brand, but that feature does not eliminate the possibility that particular short-lived model design features or other fluctuating characteristics could have important effects on a consumer's decision in a particular year.

³ The first component of the superindex denotes the orientation of the consumer, whereas the second component denotes with which firm the consumer has an inherited customer relationship.

⁴ Random relocation, i.e. preferences developing independently over time, was introduced into the switching cost literature by von Weizsäcker (1984) as a technical assumption to smooth demand and thereby guarantee the existence of a Nash equilibrium with price competition. The influential models by Klemperer (1987a, 1987b) apply a variety of this idea by assuming that a certain proportion of the consumers have persistent preferences and face infinite switching costs, whereas the complementary proportion consumers exit and is replaced by an identical number of consumers with an identical distribution of preferences. Villas-Boas (2014) presents an concentrated overview of different existing models of competition capturing switching costs.

We assume that prior to the period-1 product choice consumers know the distribution from which their generic valuation is drawn, more precisely that $v = v^H$ or $v = v^L$ with equal probabilities. However, the individual consumer is not aware of the realization of his or her idiosyncratic generic valuation until experience from the period-1 consumption has been gained. It should nevertheless be emphasized that the generic valuation v stays invariant across periods, whereas the period-specific preference captured by the location x fluctuates randomly across periods.

In period 1, a consumer located at x and facing period-1 prices p_1^A and p_1^B has an expected discounted utility consisting of the probability-weighted sum of two components: the expected discounted utility if the consumer is A-oriented and that if the consumer is B-oriented. Formally,

$$Eu_1(x) = \frac{1}{2}Eu_1^A(x) + \frac{1}{2}Eu_1^B(x), \quad (3a)$$

where the period-1 discounted utility for an A-oriented consumer is

$$Eu_1^A(x) = \begin{cases} v^H - p_1^A - tx + \delta Eu_2^{A,A}(x), & \text{if selecting A} \\ v^L - p_1^B - t(1-x) + \delta Eu_2^{A,B}(x), & \text{if selecting B} \end{cases}, \quad (3b)$$

the period-1 discounted utility for an B-oriented consumer is

$$Eu_1^B(x) = \begin{cases} v^L - p_1^A - tx + \delta Eu_2^{B,A}(x), & \text{if selecting A} \\ v^H - p_1^B - t(1-x) + \delta Eu_2^{B,B}(x), & \text{if selecting B} \end{cases}, \quad (3c)$$

and where $\delta < 1$ denotes the common discount factor. In (3b) $Eu_2^{A,A}(x)$ and $Eu_2^{A,B}(x)$ denote the expected second-period utility for an A-oriented consumer selecting firm A and firm B in period 1, respectively, whereas $Eu_2^{B,A}(x)$ and $Eu_2^{B,B}(x)$ denote the expected second-period utility for a B-oriented consumer selecting firm A and firm B in period 1, respectively. The expected discounted utility described by (3a)-(3c) captures the idea that the generic valuation is constant across periods, whereas there is a random relocation with respect to x .

Finally, we impose the following restrictions on the parameters of the model.

Assumption 1 (a) *The transportation cost parameter exceeds the idiosyncratic brand preference. Formally, $t > \Delta$.*

(b) The switching cost is restricted according to $0 < s < 3(t - \Delta)$.

Assumption 1 (a) captures the idea that the differentiation in the product market is sufficiently strong relative to the differences in generic preferences. In particular, it means that the product choice is not completely determined by the generic preferences for all consumers, but that the period-specific component of the preferences is decisive for at least some consumers. Assumption 1 (b) in its turn imposes a restriction on the magnitude of the switching costs. It implies market segmentations in period 2 with the feature that some consumers stay loyal to their period-1 supplier, whereas other consumers switch. As we will see, Assumptions 1 (a) and (b) imply feasible market segmentations in period 2 such that in each of the configurations at least some consumers switch.

3. History-based Pricing

In this section we assume that firms are able to condition period-2 prices on consumer history, but they cannot condition period-2 prices on any observations regarding the preferences of individual consumers, neither the generic component (v) nor the period-specific component (x). We refer to this type of period-2 pricing as history-based pricing.

3.1 Price Competition in Period 2

Consider a consumer belonging to A 's inherited market segment. In light of the period-2 utility function (1), the location of an A -oriented consumer indifferent between staying loyal to A at price p_2^A and switching to B at price q_2^B , $x_2^{A,A}$, is given by $v^H - p_2^A - t x_2^{A,A} = v^L - q_2^B - t(1 - x_2^{A,A}) - s$, implying that

$$x_2^{A,A} = \frac{1}{2} + \frac{q_2^B - p_2^A + s + \Delta}{2t} . \quad (4)$$

A-oriented consumers with $x \leq x_2^{A,A}$ remain loyal to A, whereas consumers with $x > x_2^{A,A}$ switch to B. Similarly, in A's inherited market segment the location of a B-oriented consumer indifferent between staying loyal to A at price p_2^A and switching to B at price q_2^B , $x_2^{B,A}$, is given by $v^L - p_2^A - t x_2^{B,A} = v^H - q_2^B - t(1 - x_2^{B,A}) - s$, from which it follows that

$$x_2^{B,A} = \frac{1}{2} + \frac{q_2^B - p_2^A + s - \Delta}{2t} . \quad (5)$$

The period-2 market segmentation for consumers with a customer relationship with firm B can be derived in a completely analogous way.

Suppose that the total number of consumers belonging to A's market segment inherited from period 1 is x_1 . Then, the number of A-oriented consumers who stay loyal to firm A is $x_1 x_2^{A,A}$, whereas in A's inherited market segment the number of A-oriented consumers switching to B is $x_1(1 - x_2^{A,A})$. Similarly, the number of A-oriented consumers switching from B to A is given by $(1 - x_1)(1 - x_2^{A,B})$, where

$$x_2^{A,B} = \frac{1}{2} + \frac{q_2^A - p_2^B + s - \Delta}{2t} . \quad (6)$$

And, the number of B-oriented consumers switching to A is given by $(1 - x_1)(1 - x_2^{B,B})$, where

$$x_2^{B,B} = \frac{1}{2} + \frac{q_2^A - p_2^B + s + \Delta}{2t} . \quad (7)$$

With the relevant market segments defined by (4) – (7) the second period profit maximization problem facing firm A is given by

$$\max_{p_2^A, q_2^A} \pi_2^A(p_2^A, q_2^A, p_2^B, q_2^B) = x_1 p_2^A (x_2^{A,A} + x_2^{B,A}) + (1 - x_1) q_2^A ((1 - x_2^{A,B}) + (1 - x_2^{B,B})) . \quad (8)$$

This objective function captures the idea that firm A charges those consumers with whom it has an established customer relationship in period 1 its loyalty price p_2^A . The number of such

consumers is $x_1 (x_2^{A,A} + x_2^{B,A})$ as some of these consumers are A-oriented, whereas others are B-oriented. Furthermore, firm A targets its poaching price q_2^A to consumers belonging to firm B's inherited market segment. This segment includes consumers who are A- as well as B-oriented and the total number of such consumers is $(1 - x_1) ((1 - x_2^{A,B}) + (1 - x_2^{B,B}))$.

In a completely analogous way the second period optimization problem facing firm B is given by

$$\max_{p_2^B, q_2^B} \pi_2^B(p_2^B, q_2^B, p_2^A, q_2^A) = (1 - x_1) p_2^B (x_2^{B,B} + x_2^{A,B}) + x_1 q_2^B ((1 - x_2^{B,A}) + (1 - x_2^{A,A})). \quad (9)$$

Substituting (4) – (7) into (8) and (9) we find that the period-2 equilibrium prices are

$$p_2^A = p_2^B = p_2^{NR} = t + \frac{s}{3} \quad \text{and} \quad q_2^A = q_2^B = q_2^{NR} = t - \frac{s}{3}, \quad (10)$$

where the superindex *NR* refers to the equilibrium with history-based pricing with no recognition of consumer-specific preferences. The price equilibrium (10) captures the intuition that the loyalty price exhibits a premium ($s/3$), determined by the switching cost, relative to the static Hotelling equilibrium (t), whereas the poaching price exhibits a discount ($s/3$) of equal magnitude.

Substituting the price equilibrium (10) back into (4)-(7) yields the thresholds

$$x_2^{A,A} = x_2^{B,B} = x_2^{NR,H} = \frac{1}{2} + \frac{s}{6t} + \frac{\Delta}{2t} \quad \text{and} \quad x_2^{B,A} = x_2^{A,B} = x_2^{NR,L} = \frac{1}{2} + \frac{s}{6t} - \frac{\Delta}{2t}, \quad (11)$$

which determine the market segmentation in equilibrium. According to Assumption 1 (a) and (b) these thresholds belong to the unit interval, meaning that the implied market segmentation is feasible. In particular, we see that the equilibrium has the intuitive property that the market share for a variety is higher among consumers with a persistent preference for this variety than the market share for its rival. Further, a firm's market share among existing customers is increasing as a function of the switching cost protecting such established customer relationships.

By substituting (10) and (11) into (8) and (9), we find that the equilibrium profits can be written as

$$\pi_2^{A,NR} = x_1 \frac{1}{t} \left(t + \frac{s}{3} \right)^2 + (1-x_1) \frac{1}{t} \left(t - \frac{s}{3} \right)^2 ,$$

$$\pi_2^{B,NR} = (1-x_1) \frac{1}{t} \left(t + \frac{s}{3} \right)^2 + x_1 \frac{1}{t} \left(t - \frac{s}{3} \right)^2 .$$

The period-2 equilibrium profits consist of two components. The first term is the incumbency profit and the second term is the poaching profit. Both terms are proportional to the market share acquired in period 1, but these dependencies are of opposite signs: the incumbency profit is an increasing and the poaching profit is a decreasing function of this market share. Similarly, the incumbency profit is an increasing and the poaching profit is a decreasing function of the switching cost.

By collecting the terms, we find that the equilibrium profits can be written as

$$\pi_2^{A,NR} = x_1 \frac{4s}{3} + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 , \quad (12a)$$

$$\pi_2^{B,NR} = (1-x_1) \frac{4s}{3} + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 . \quad (12b)$$

As we emphasized above, a larger market share acquired in period 1 increases incumbency profits and decreases poaching profits in period 2. When competing in period 1, each firm must take both these effects into account. The latter negative effect on poaching profit undermines the former positive effect on incumbency profit. The residual net effect, dominated by the incumbency profit component, is of magnitude $4s/3$ and we will see below that this net effect determines the magnitude of the price discount that firms introduce to attract customers in the first period.

3.2 Price Competition in Period 1

We next shift our attention to price competition in period 1. We assume the consumers to anticipate how their selection of supplier in period 1 affects their options in period 2, keeping in mind the random reallocation of locations between periods. Furthermore, the consumers only know the distribution from which their generic valuation is drawn, but not the associated realization, at the time when they make their period-1 decision.⁵ The consumers as well as the firms apply a common discount factor, δ .

We denote by x_1 the period-1 location of the consumer indifferent between supplier A, offering the period-1 price p_1^A , and supplier B, competing with price p_1^B . This indifferent consumer is determined by the condition

$$\begin{aligned} & \frac{1}{2}(v^H + v^L) - p_1^A - t x_1 + \frac{\delta}{2} \left[x_2^{A,A} (v^H - p_2^A) - t \int_0^{x_2^{A,A}} x dx + (1 - x_2^{A,A})(v^L - q_2^B - s) - t \int_{x_2^{A,A}}^1 (1-x) dx \right] + \\ & \frac{\delta}{2} \left[x_2^{B,A} (v^L - p_2^A) - t \int_0^{x_2^{B,A}} x dx + (1 - x_2^{B,A})(v^H - q_2^B - s) - t \int_{x_2^{B,A}}^1 (1-x) dx \right] = \frac{1}{2}(v^H + v^L) - p_1^B \\ & - t(1 - x_1) + \frac{\delta}{2} \left[(1 - x_2^{A,B})(v^H - q_2^A - s) - t \int_0^{x_2^{A,B}} (1-x) dx + x_2^{A,B} (v^L - p_2^B) - t \int_{x_2^{A,B}}^1 x dx \right] + \\ & \frac{\delta}{2} \left[(1 - x_2^{B,B})(v^L - q_2^A - s) - t \int_0^{x_2^{B,B}} (1-x) dx + x_2^{B,B} (v^H - p_2^B) - t \int_{x_2^{B,B}}^1 x dx \right]. \end{aligned}$$

This condition equalizes the sum of the expected period-1 utility and the expected discounted value of the period-2 utility to the consumer who is indifferent between firm A's and firm B's offer in period 1. This indifference condition captures the feature that, when making the period-1 decision, the consumer rationally anticipates the expected discounted utility associated with each of the configurations which may emerge in period 2. The different configurations emerge because of the random fluctuation in period-specific preferences (relocation), and for each of the configurations a particular combination of period-2 prices applies. The seemingly complicated indifference condition above formalizes precisely this.

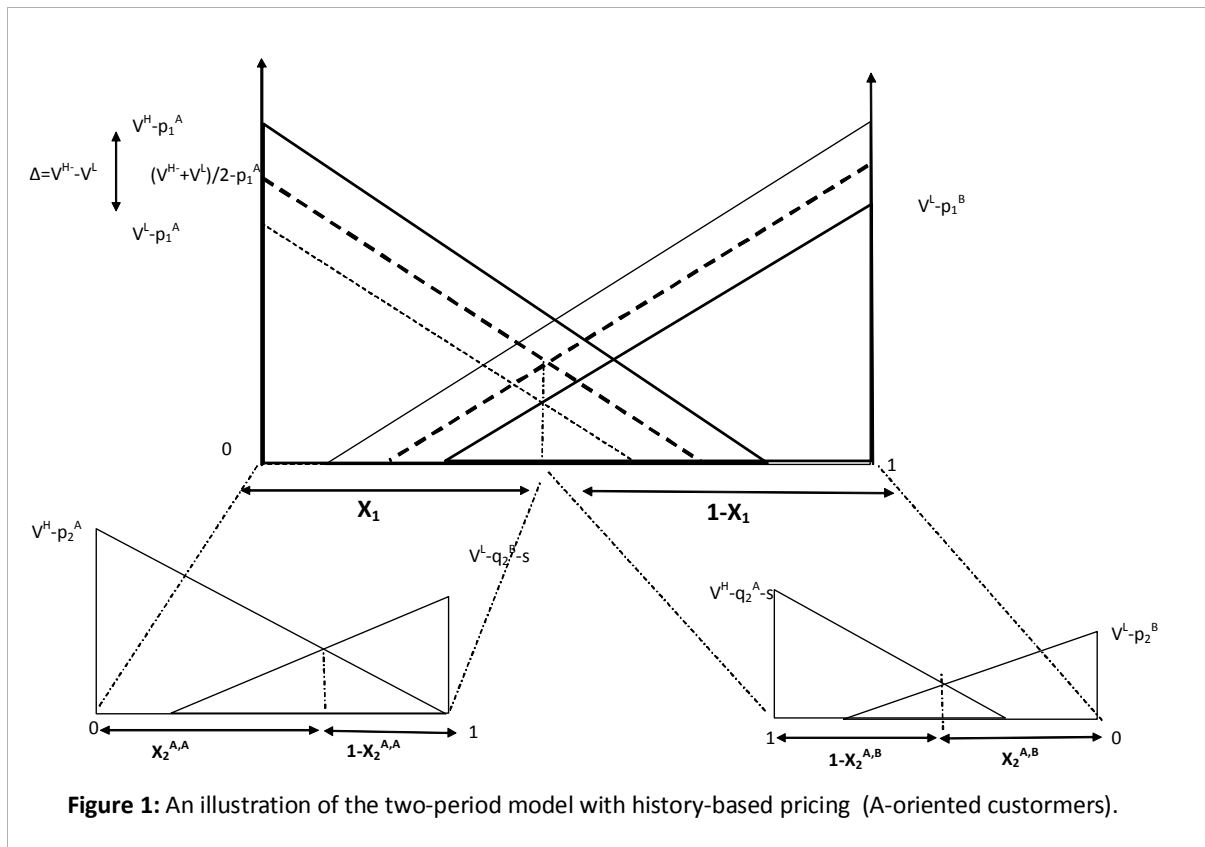
⁵ Without this assumption, consumers could, conditional on whether they are A- or B-oriented, be willing to strategically adjust their period-1 decisions in order to benefit from attractive poaching offers in period 2. Such strategic behavior is excluded by the assumption that consumers do not know their generic valuation prior to their period-1 decision. This assumption significantly adds to the tractability of the analysis.

Substituting the second-period equilibrium prices (8) and market shares (9) into this indifference condition we find that

$$x_1 = \frac{1}{2} + \frac{p_1^B - p_1^A}{2t}. \quad (13)$$

The location of indifference is determined in an analogous way for B-oriented consumers.

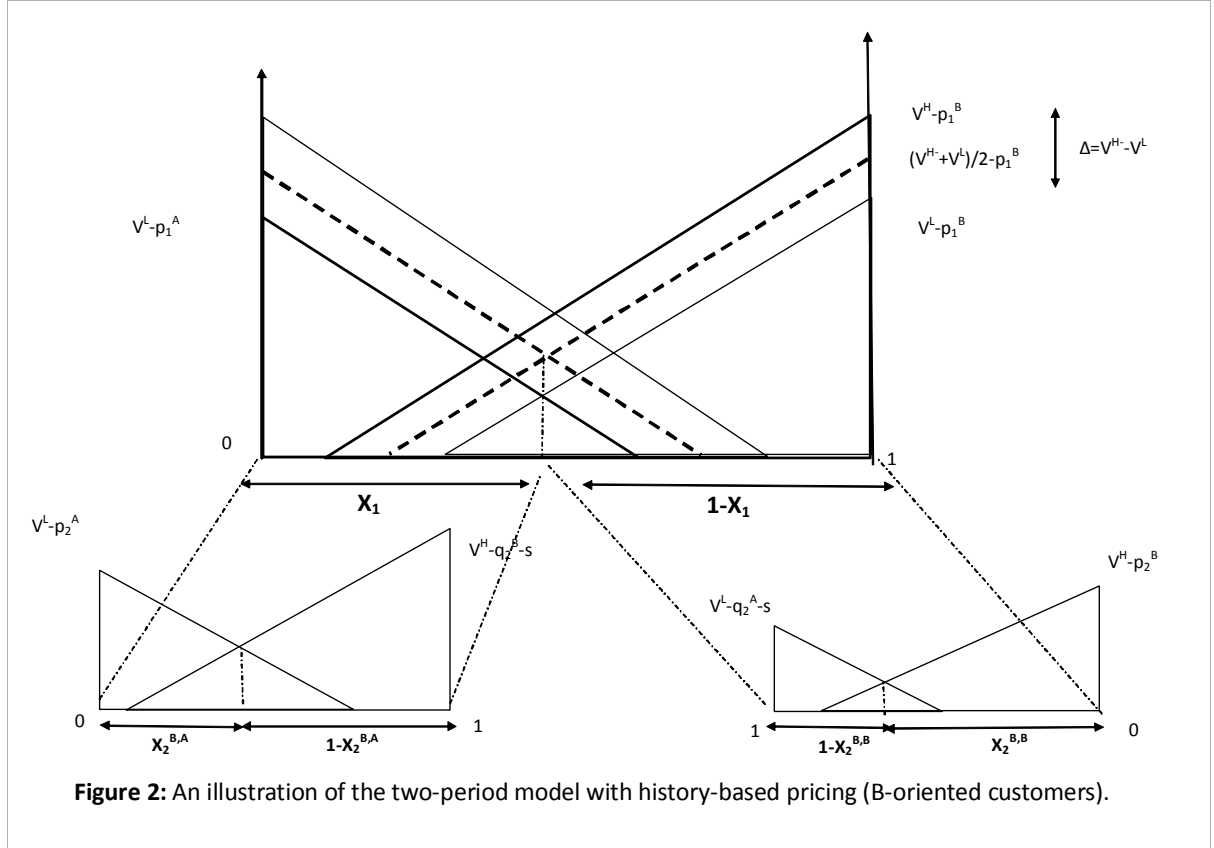
Figure 1 illuminates the dynamics of two-period model with history-based pricing for A-oriented consumers. The lower part of Figure 1 captures how the customer relationships inherited from period 1 together with the relocation in period 2 determine the market segmentation in period 2. The left-hand side in the lower part of Figure 1 illustrates the market segmentation for consumers with an inherited customer relationship with firm A. The threshold $x_2^{A,A}$ is formally characterized by (4). Analogously, the right-hand side in the lower part of Figure 1 depicts the period-2 market segmentation for consumers belonging to firm B's



inherited market segment. The threshold $x_2^{A,B}$ is formally described by (6). The upper part of Figure 1 delineates how the market segmentation in period 1 is determined at the stage when the consumer does not yet know the realization of his/her idiosyncratic generic preferences. In

particular, Figure 1 portrays how the market segmentations for A-oriented consumers in the first and second periods are intertwined.

Figure 2 illustrates history-based pricing for B-oriented consumers. Figure 2 is constructed in a way analogous to Figure 1. In Figure 2, the market segmentations in period 2 are determined by $x_2^{B,A}$ and $x_2^{B,B}$, formally characterized in (5) and (7), respectively.



In period 1, firms engage in price competition in order to maximize the discounted value of the two-period profits according to

$$\max_{p_1^A} \Gamma^A(p_1^A, p_1^B) = 2p_1^A x_1 + \delta \left[x_1 \frac{4s}{3} + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 \right], \quad (14a)$$

$$\max_{p_1^B} \Gamma^B(p_1^B, p_1^A) = 2p_1^B (1 - x_1) + \delta \left[(1 - x_1) \frac{4s}{3} + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 \right], \quad (14b)$$

with x_1 given by (13) and with (12a) and (12b) substituted into (14a) and (14b), respectively, for the period-2 equilibrium profits. The factor 2 in the first-period component of the profit

functions (14a) and (14b) captures the feature that there is a unit measure of both A- and B-oriented consumers.

Solution of the maximization problems (14a) and (14b) yields the period-1 equilibrium prices

$$p_1^A = p_2^B = p_1^{NR} = t - \frac{\delta}{2} \frac{4s}{3} \quad (15)$$

In a static one-period Hotelling model, the equilibrium prices equal t . Compared with the static one-period model, the first-period prices are lower and exhibit an introductory discount of magnitude $\frac{\delta}{2} \frac{4s}{3}$. This introductory discount perfectly reflects the discounted net effect of higher market share on second period profits, captured by the market share coefficients in (12a) and (12b). Furthermore, the resulting first-period market shares in the present model coincide with those in the static Hotelling model:

$$x_1^{NR} = \frac{1}{2}. \quad (16)$$

Thus, in equilibrium intensified period-1 competition for customers has no impact on equilibrium market shares but only reduces first-period prices.

Substitution of (15) and (16) back into (14a) and (14b) yields the discounted value of the two-period equilibrium profits

$$\Gamma^A = \Gamma^B = \Gamma^{NR} = t + \frac{\delta}{t} \left(t - \frac{s}{3} \right)^2. \quad (17)$$

In (17) the discounted sum of profits is decomposed into the profit associated with horizontal product differentiation, $t/2$ in each market segment (A- and B-oriented), and discounted profits associated with poaching activities in the second period. The profits associated with poaching activities equal $(\delta/2) \times (1/t) (t - s/3)^2$ for both A- and B-oriented consumers. The subgame perfect equilibrium prices exhibit an intertemporal structure with introductory discounts in period 1 followed by mark-ups determined by the switching costs in period 2, as formally captured by (15) and (10). In equilibrium, competition in period 1 is precisely so intense as to eliminate the period-2 profit component associated with the market share acquired in period 1

(the first term in (12a) and (12b), respectively). This means that period-1 competition for the formation of customer relationships is precisely so intense so as to neutralize the incumbency rents which can be made from customers locked-in by the switching costs in period 2⁶.

According to (10) and (15), the switching costs determine inter-temporal price dispersion, i.e. the volatility of the price fluctuations across periods. Likewise, they determine the difference between the loyalty prices and the poaching prices in period 2.

We summarize our findings regarding history-based pricing with no consumer recognition in the following result.

Result 1 *Period-1 competition for the formation of customer relationships is precisely so intense so as to neutralize the incumbency rents which can be made from customers locked-in by the switching costs in period 2. The surviving two-period equilibrium profits in (15) can be decomposed into the period-1 profit associated with horizontal product differentiation and the profits associated with poaching activities in period 2.*

4. Personalized Pricing with Recognition of Consumer Preferences

As in the previous section, in this section we also assume that each firm can distinguish its own period-1 customers from those of its rival, thereby facilitating a separation of loyalty prices and poaching prices. In addition, in this section we assume that the firms are able to acquire customer-specific information regarding the generic component of their customers' preferences (v) as a basis for the period-2 pricing decisions. This means, more precisely, that each firm can condition its period-2 *loyalty* price on observations regarding the idiosyncratic parameter v for each of its customers with whom it formed a customer relationship in period 1. This reflects the idea that the period-1 transaction reveals information about the customer's generic preference for the firm's product.

⁶ Similar intertemporal properties of the price equilibrium and the associated equilibrium profits were established in Gehrig and Stenbacka (2004), where the switching costs were determined by long-term decisions regarding product differentiation.

We assume that the firm cannot identify the type of a consumer who bought from its rival in period 1. Therefore it cannot condition the *poaching* price in period 2 on customer-specific information regarding v .

4.1 Price Competition in Period 2

To start with, consider consumers with whom firm A has established a customer relationship in period 1. With customer recognition, we let $p_2^{A,A}$ and $p_2^{B,A}$ denote the period-2 price, which firm A offers to A-oriented and B-oriented customers, respectively. The market segmentation in period 2 is then determined by the two indifference conditions

$$v^H - p_2^{A,A} - t x_2^{A,A} = v^L - q_2^B - t(1 - x_2^{A,A}) - s \quad \text{and}$$

$$v^L - p_2^{B,A} - t x_2^{B,A} = v^H - q_2^B - t(1 - x_2^{B,A}) - s$$

for the A-oriented and B-oriented customers of firm A, respectively. From these indifference conditions it follows that firm A has the market share

$$x_2^{A,A} = \frac{1}{2} + \frac{q_2^B - p_2^{A,A} + s + \Delta}{2t} \quad (18)$$

among its inherited A-oriented customers and the market share

$$x_2^{B,A} = \frac{1}{2} + \frac{q_2^B - p_2^{B,A} + s - \Delta}{2t} \quad (19)$$

among its inherited B-oriented customers. Similarly,

$$x_2^{B,B} = \frac{1}{2} + \frac{q_2^A - p_2^{B,B} + s + \Delta}{2t} \quad (20)$$

and

$$x_2^{A,B} = \frac{1}{2} + \frac{q_2^A - p_2^{A,B} + s - \Delta}{2t} \quad (21)$$

are firm B 's market shares among its B -oriented and A -oriented customers, respectively.

As in the previous section, we let x_1 denote the total number of consumers belonging to A 's market segment inherited from period 1. Then, the number of A -oriented consumers who stay loyal to firm A is $x_1 x_2^{A,A}$, whereas the number of A -oriented consumers switching to B is $x_1 (1 - x_2^{A,A})$. Similarly, the number of A -oriented consumers switching from B to A is given by $(1 - x_1)(1 - x_2^{A,B})$, whereas the number of A -oriented consumers, who stay loyal to B , is given by $(1 - x_1)x_2^{A,B}$ (see figures 1 and 2 above). The decomposition of B -oriented consumers in period 2 follows an analogous pattern.

With the relevant market segments defined by (18) – (21) the second period profit maximization problem of firm A is given by

$$\max_{p_2^{A,H}, p_2^{A,L}, q_2^A} \pi_2^A = x_1 (x_2^{A,A} p_2^{A,A} + x_2^{B,A} p_2^{B,A}) + (1 - x_1) q_2^A ((1 - x_2^{A,B}) + (1 - x_2^{B,B})). \quad (22)$$

Analogously, the second period optimization problem of firm B is given by

$$\max_{p_2^{B,H}, p_2^{B,L}, q_2^B} \pi_2^B = (1 - x_1) (x_2^{B,B} p_2^{B,B} + x_2^{A,B} p_2^{A,B}) + x_1 q_2^B ((1 - x_2^{B,A}) + (1 - x_2^{A,A})). \quad (23)$$

Substituting (18) – (21) into (22) and (23) we find that the period-2 equilibrium loyalty prices with customer recognition are

$$p_2^{A,A} = p_2^{B,B} = p_2^{R,H} = t + \frac{s}{3} + \frac{\Delta}{2}, \quad \text{and} \quad p_2^{B,A} = p_2^{A,B} = p_2^{R,L} = t + \frac{s}{3} - \frac{\Delta}{2}, \quad (24a)$$

and that the equilibrium poaching prices are

$$q_2^A = q_2^B = q_2^R = t - \frac{s}{3}. \quad (24b)$$

In the equilibrium prices (24a) and (24b) the superindex R refers to the personalized pricing regime with preference recognition of individual customers.

Comparing the pair of maximization problems (8) and (9) with (22) and (23) we can observe that recognition of individual customer preferences increases the number of price instruments available to an individual firm from two to three, thus facilitating a higher degree of price

discrimination by the incumbent firms. Based on a comparison of the period-2 equilibrium prices with and without this type of customer recognition we can draw a number of interesting conclusions. From (10) and (24b) we observe that the poaching prices are invariant to whether there is personalized pricing or not. This makes sense because the considered customer recognition does not extend to the consumers belonging to the rival's inherited customer segment. Further, from (10) and (24a) we can observe that the average loyalty price is unaffected by personalized pricing. However, personalized pricing introduces dispersion in the loyalty prices because with preference recognition these prices are set contingent on the customer's orientation. The magnitude of this dispersion is determined by the preference premium, Δ .

Substituting the price equilibrium characterized by (24a) and (24b) back into (18)-(21) yields the equilibrium thresholds

$$x_2^{A,A} = x_2^{B,B} = x_2^{R,H} = \frac{1}{2} + \frac{s}{6t} + \frac{\Delta}{4t} \quad \text{and} \quad x_2^{B,A} = x_2^{A,B} = x_2^{R,L} = \frac{1}{2} + \frac{s}{6t} - \frac{\Delta}{4t}, \quad (25)$$

which determine the equilibrium market segmentation with personalized pricing⁷. The thresholds characterized by (25) determine the period-2 frequency of switching with personalized pricing. In particular, by comparing (25) with (11) we can see that $x_2^{R,L} > x_2^{NR,L}$, which means that with recognition of customer preferences there will be a lower degree of switching in equilibrium among consumers matched with the brand for which they have a low generic preference. As the switching of these *L*-type consumers takes place in the direction towards the more valued brand, this means that with personalized pricing a lower number of consumers engage in *efficient* switching. Furthermore, by comparing (25) with (11) we also observe that $x_2^{R,H} < x_2^{NR,H}$, which means that personalized pricing will induce a higher number of consumers already matched with their favorite brand to switch. As the switching of these *H*-type consumers takes place in the direction towards the low-valuation brand, this implies that with personalized pricing a higher number of consumers engage in *inefficient* switching.

⁷ Again, Assumption 1 (a) and (b) guarantee that these equilibrium thresholds are feasible, i.e. that they belong to the unit interval.

By substituting the period-2 equilibrium prices (24a) and (24b) as well as the equilibrium thresholds (25) into (22) and (23) we find that the equilibrium profits in period 2 can be written as

$$\pi_2^{A,R} = x_1 \left(\frac{1}{t} \left(t + \frac{s}{3} \right)^2 + \frac{\Delta^2}{4t} \right) + (1-x_1) \frac{1}{t} \left(t - \frac{s}{3} \right)^2 ,$$

$$\pi_2^{B,R} = (1-x_1) \left(\frac{1}{t} \left(t + \frac{s}{3} \right)^2 + \frac{\Delta^2}{4t} \right) + x_1 \frac{1}{t} \left(t - \frac{s}{3} \right)^2 .$$

As in the regime with history-based pricing, the period-2 equilibrium profits consist of two components: the incumbency profit and the poaching profit. These profits terms both depend linearly on the market share, but the dependency is of opposite signs: the incumbency profit increases and the poaching profit decreases in the market share acquired in the first period. Likewise as in history-based pricing, the incumbency profit increases and the poaching profit decreases in the switching costs. In fact, for a given inherited market share, the poaching profits are independent of the pricing mechanism, whereas the incumbency profit are higher when personalized pricing is applied. The difference in the incumbency profits between personalized pricing and history-based pricing depends positively on the generic preference premium Δ ($x_1 \Delta^2 / (4t)$). As will be shown later, this additional incumbency profit implies intensified price competition in the first period under personalized pricing. This competition-enhancing effect in period 1 will precisely neutralize the higher period-2 profits under the personalized pricing regime. Notice also that, with personalized pricing, the incumbency profits increase as a function of the preference premium – a feature capturing the idea that the value of customer recognition is higher the higher is the difference in the willingness to pay across the two different consumer types.

By collecting the terms we find that the equilibrium profits in period 2 can be written as

$$\pi_2^{A,R} = x_1 \left(\frac{4s}{3} + \frac{\Delta^2}{4t} \right) + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 , \quad (26a)$$

$$\pi_2^{B,R} = (1-x_1) \left(\frac{4s}{3} + \frac{\Delta^2}{4t} \right) + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 . \quad (26b)$$

When competing in period 1, each firm must take into account that the marginal effect of a higher first period market share is of magnitude $4s/3 + \Delta^2/(4t)$. We will see in the next subsection that this term determines the magnitude of the first-period price discount, whereby firms attract customers in the first period.

4.2 Price Competition in Period 1

Following a procedure identical to that of the previous section, we next focus on price competition in period 1. Applying the same procedure, we let x_1 denote the period-1 location of the consumer indifferent between supplier A, offering the period-1 price p_1^A , and supplier B, competing with price p_1^B . Since personalized pricing discriminates between the generic preference types, the location of an A-oriented indifferent consumer is now determined by the condition

$$\begin{aligned} & \frac{1}{2}(v^H + v^L) - p_1^A - t x_1 + \frac{\delta}{2} \left[x_2^{A,A} (v^H - p_2^{A,A}) - t \int_0^{x_2^{A,A}} x dx + (1-x_2^{A,A})(v^L - q_2^B - s) - t \int_{x_2^{A,A}}^1 (1-x) dx \right] + \\ & \frac{\delta}{2} \left[x_2^{B,A} (v^L - p_2^{B,A}) - t \int_0^{x_2^{B,A}} x dx + (1-x_2^{B,A})(v^H - q_2^B - s) - t \int_{x_2^{B,A}}^1 (1-x) dx \right] = \frac{1}{2}(v^H + v^L) - p_1^B \\ & - t(1-x_1) + \frac{\delta}{2} \left[(1-x_2^{A,B})(v^H - q_2^B - s) - t \int_0^{x_2^{A,B}} (1-x) dx + x_2^{A,B} (v^L - p_2^{A,B}) - t \int_{x_2^{A,B}}^1 x dx \right] + \\ & \frac{\delta}{2} \left[(1-x_2^{B,B})(v^L - q_2^A - s) - t \int_0^{x_2^{B,B}} (1-x) dx + x_2^{B,B} (v^H - p_2^{B,B}) - t \int_{x_2^{B,B}}^1 x dx \right]. \end{aligned}$$

This indifference condition is constructed in a way identical to the associated indifference condition without customer recognition. Thus, the only difference compared with history-based pricing is that the incumbency prices in period 2 are now type-contingent.

Substituting the second-period equilibrium prices (24a) and (24b) as well as the market shares (25) into this indifference condition we find that $x_1 = \frac{1}{2} + \frac{p_1^B - p_1^A}{2t}$, which is formally unchanged compared with (13). A similar procedure is applied to find the location of the indifferent B-oriented consumer.

Firms A and B set the period-1 prices in order to maximize the discounted value of the two-period profits according to

$$\max_{p_1^A} \Gamma^A(p_1^A, p_1^B) = 2p_1^A x_1 + \delta \left[x_1 \left(\frac{4s}{3} + \frac{\Delta^2}{4t} \right) + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 \right], \quad (27a)$$

$$\max_{p_1^B} \Gamma^B(p_1^B, p_1^A) = 2p_1^B (1 - x_1) + \delta \left[(1 - x_1) \left(\frac{4s}{3} + \frac{\Delta^2}{4t} \right) + \frac{1}{t} \left(t - \frac{s}{3} \right)^2 \right], \quad (27b)$$

where $x_1 = \frac{1}{2} + \frac{p_1^B - p_1^A}{2t}$ and where we have directly substituted the period-2 equilibrium profits (26a) and (26b) into (27a) and (27b), respectively.

Solution of the maximization problems (27a) and (27b) yields the period-1 equilibrium prices and associated market share

$$p_1^A = p_2^B = p_1^R = t - \frac{\delta}{2} \left(\frac{4s}{3} + \frac{\Delta^2}{4t} \right) \quad \text{and} \quad x_1^R = \frac{1}{2}. \quad (28)$$

From (28) we can observe an introductory price discount in period 1, precisely as in the regime with history-based pricing. Yet, with personalized pricing this introductory discount is larger than with history-based pricing, by a magnitude of $\Delta^2/(4t)$. This reflects the fact that personalized pricing facilitates preference recognition of own customers in period 2, which leads to higher period-2 profits as a comparison of (26a) and (26b) with (12a) and (12b) reveals. Comparing personalized pricing with history-based pricing also reveals that the first-period additional price discount is of precisely the same magnitude as the increment in the second-period incumbency profits, thus perfectly neutralizing the profit difference. Indeed,

substitution of (28) back into (27a) and (27b) yields the discounted value of the two-period equilibrium profits

$$\Gamma^A = \Gamma^B = \Gamma^R = t + \frac{\delta}{t} \left(t - \frac{s}{3} \right)^2, \quad (29)$$

which coincide with the discounted profits in the case of history-based pricing, (17). Thus we reach the conclusion that the two-period profits are invariant to whether the firms apply personalized or history-based pricing. Furthermore, as in the case of history-based pricing, the equilibrium profits (29) can be decomposed into the period-1 profits associated with static horizontal differentiation (Hotelling profits) and the profits associated with poaching activities in period 2.

Our model exhibits profit neutrality with respect to the pricing system (personalized or history-based) as long as profits are evaluated over the whole two-period horizon. Nevertheless, the inter-temporal fluctuations of the incumbency prices are stronger with personalized pricing: a larger price discount in period 1 followed by a higher mark-up in period 2. Moreover, pricing conditional on customer preferences enhances the inter-temporal volatility of the profits, and the volatility grows as a function of the preference premium (Δ).

We summarize our findings regarding personalized pricing according to the following result.

Result 2 *Discounted two-period profits are invariant to whether personalized pricing or history-based pricing is applied when evaluated over a two-period horizon. However, individualized pricing enhances inter-temporal price volatility and this volatility increases with the preference premium.*

It should be emphasized that the horizon plays a significant role when evaluating the effects of personalized pricing. As our analysis of price competition in period 2 makes clear, personalized pricing promotes industry profits when focusing on exogenously given market shares with already established customer relationships. However, when extending the analysis to take the dynamic effects of personalized pricing into account, our model has the neutrality property according to which the sum of the discounted profits is invariant to whether firms apply

history-based or personalized pricing. Indeed the period-1 introductory discounts serve as investments for the acquisition of customer relationships and thereby for customer-specific information about the preferences of individual customers, thus rendering the inherited clientele endogenous in our model.⁸

5. Welfare Analysis and Policy Implications

In this section we explore the consequences of personalized pricing and history-based pricing for consumer surplus and total welfare. This is particularly relevant from the perspective of privacy and competition policy.

Of course, consumer surplus and total welfare could be calculated in a mechanical way by substituting the appropriate equilibrium prices and market shares into the formula defining consumer surplus and total welfare, respectively. To better understand and highlight the economic mechanisms involved we adopt an alternative approach and exploit some of the particular features of our model and of the results derived so far. We focus on total welfare defined as the sum of consumer surplus and industry profits.

In general, Hotelling competition focuses on markets of a fixed size, implying that price changes simply represent redistributions of surplus between consumers and producers without effects on total welfare. However, switching costs and transportation costs constitute losses of total welfare in the economy. In our ex-ante symmetric model, price competition in period 1 results in an equal split of the customer base in the first period. Therefore there are no differences in welfare in period 1 across the two pricing regimes. But, because there are different switching thresholds between the two pricing systems in period 2, the two pricing regimes will potentially generate different aggregate switching and transportation costs in period 2. This establishes the basis for why the two pricing regimes lead to different total welfare in period 2.

Making use of the notation defined in (11) and (25), respectively, total welfare in period 2 is given by

⁸ In the introduction we enlist a number of studies with alternative mechanisms for information acquisition.

$$W_2^m = 2 \left[(x_2^{m,H} + (1 - x_2^{m,L}))v^H + (x_2^{m,L} + (1 - x_2^{m,H}))v^L \right] - 2 \left[(1 - x_2^{m,L}) + (1 - x_2^{m,H}) \right] s - 2 \left[t \int_0^{x_2^{m,H}} x dx + t \int_{x_2^{m,L}}^1 (1 - x) dx + t \int_0^{x_2^{m,L}} x dx + t \int_{x_2^{m,H}}^1 (1 - x) dx \right], \quad (30)$$

where $m=NR,R$ refers to the pricing regime: history-based or personalized pricing.

The first term in (30), $2 \left[(x_2^{m,H} + (1 - x_2^{m,L}))v^H + (x_2^{m,L} + (1 - x_2^{m,H}))v^L \right]$, captures the gross surplus to consumers in pricing regime m with $2(x_2^{m,H} + (1 - x_2^{m,L}))$ consumers enjoying their high-valuation variety, whereas $2(x_2^{m,L} + (1 - x_2^{m,H}))$ consumers are allocated to the low-valuation variety. The second term, $2 \left[(1 - x_2^{m,L}) + (1 - x_2^{m,H}) \right] s$, measures the total switching costs in equilibrium. Among the switchers, $2(1 - x_2^{m,L})$ consumers engage in efficient switching from the low-valuation variety L to the high-valuation variety H , whereas $2(1 - x_2^{m,H})$ engage in inefficient switching in the opposite direction. Finally, the third term,

$$2 \left[t \int_0^{x_2^{m,H}} x dx + t \int_{x_2^{m,L}}^1 (1 - x) dx + t \int_0^{x_2^{m,L}} x dx + t \int_{x_2^{m,H}}^1 (1 - x) dx \right],$$

denotes total transportation costs associated with the period-2 equilibrium. The factor 2 in all the terms in (30) captures the feature that there is a unit measure of both A-oriented and B-oriented consumers and thus there is a market segment of each type for each of each of the two firms.

We reach formal expressions for the total welfare with both personalized pricing and history-based pricing by substituting the equilibrium market shares (11) and (25) into (30). Such a comparison delivers the following result.

Result 3 *History-based pricing leads to higher total welfare than personalized pricing.*

Formally, $W^{NR} - W^R = \delta \frac{\Delta^2}{2t}$. In particular, this difference in total welfare strictly increases in the valuation premium and the discount factor, whereas it strictly decreases in the differentiation parameter. Notably, the welfare difference is independent of the switching costs.

For the formal proof of Result 3 we refer to the Appendix.

According to Result 3, personalized pricing is harmful for total welfare. A remarkable feature is that the welfare loss is independent of the switching costs, s . This follows from the property that the total amount of switching is invariant to the introduction of personalized pricing, as a comparison of (25) with (11) shows. However, personalized pricing leads to a higher (lower) proportion of inefficient (efficient) switching compared with history-based pricing. The economic mechanism behind this result is that a firm with information about the generic valuation sets type-contingent prices which are higher for H-type consumers, and lower for L-type consumers, compared with history based prices, as a comparison between (10) and (24a) shows.

Recall that discounted two-period profits do not depend on the pricing scheme (Result 2). Thus, in our model comparisons regarding total welfare have direct implications for consumer surplus. Based on Results 2 and 3, we can draw the following conclusion regarding consumer surplus.

Result 4 *The application of personalized pricing harms consumer surplus when evaluated over the two-period horizon.*

We can exploit our findings regarding the inter-temporal distribution of the effects of personalized pricing on equilibrium profits in order to also refine the picture regarding the per-period decomposition regarding the effects on consumer surplus. As personalized pricing leads to stronger introductory discounts than history-based pricing in period 1, it follows that the consumers benefit from the personalized pricing system in period 1. However, personalized pricing harms consumers in period 2. Furthermore, from Result 4 we can conclude that the extended discounted harm in period 2 from personalized pricing compared with history-based pricing exceeds the benefits enjoyed by consumers from intensified competition in period 1.

Overall, we can conclude that personalized pricing introduces distributional conflicts within periods as well as across periods. Consumers benefit in period 1 from personalized pricing at the expense of firms, but, as the formalized comparison in Result 3 shows, this is more than offset by that fact that personalized pricing improves the ability of firms to exploit locked-in consumers in period 2.

Our study offers a formalized analysis in support of protection of consumer privacy no matter whether the policymaker operates with consumer welfare or total welfare as the objective. The mechanism behind this conclusion centers around the feature that personalized prices enhances the ability of firms to exploit consumer surplus through the introduction of type-contingent incumbency prices. Furthermore, personalized pricing leads to more inefficient switching than history-based pricing, and this is an important explanation for the ranking of total welfare across the regimes personalized pricing and history-based pricing.

The insights of our analysis can be contrasted with those of a model with exogenously inherited market segments. Restricting attention to period 2 only, personalized pricing introduces a conflict of interest between consumers and producers: the period-2 industry profits with personalized pricing exceed those with history-based pricing, whereas the opposite ranking holds true if we consider total welfare in period 2. Thus, with exogenously inherited market segments there is a distributional conflict between firms and consumers. However, this conflict of interest disappears once we extend our perspective to a two-period horizon where the customer relationships are made endogenous. When market segmentation is endogenous consumers benefit from privacy protection, and this benefit to consumers is realized without sacrifice in terms of industry profits because the discounted two-period profits are invariant to whether personalized pricing or history-based pricing is applied. In this respect, the dynamic analysis reveals that privacy protection induce a Pareto improvement.

It should be emphasized that the arguments developed in this study against personalized pricing are solely based on economic efficiency. If in addition privacy protection has an intrinsic value associated with the respect for individual integrity typical for western democracies, there are even stronger reasons for a skeptical view towards personalized prices.

6. Concluding Comments

We have compared personalized pricing and history-based pricing and shown that personalized pricing is harmful for consumer surplus and total welfare when evaluated over a two-period horizon. In our two-period setup, the consumers benefit from privacy protection without any sacrifice in industry profits. The key mechanism behind this welfare conclusion is that the discounted two-period profits are invariant to whether personalized pricing or history-

based pricing is applied and that the total switching costs are constant across the pricing regimes. Thus, the pricing scheme that performs better in allocating each customer to the product for which they have generic preferences is also better for welfare. Our analysis reveals that personalized pricing leads to a higher (lower) proportion of inefficient (efficient) switching compared with history-based pricing.

The two-period horizon is important from the perspective of our welfare conclusions. With a one-period horizon characterized by exogenously inherited market segments, the choice of pricing system has no effect on total welfare, but personalized pricing introduces a distributional conflict between firms and consumers.

Of course, the welfare results concerning and the invariance of profits are specific to our Hotelling model with uniformly distributed consumers. The main economic insights nevertheless seem to hold true more generally: if one pricing regime generates higher profits with exogenously given customer relationships, then competition for customer relationships will be more intense, leading to lower profits in that regime. This mechanism tends to equalize incumbency profits across the pricing regimes. Furthermore, in our model with established customer relationships as the only instrument for acquisition of customer-specific information, poaching profits and thereby also discounted two-period profits are invariant to whether firms apply personalized pricing or history-based pricing. The second important component behind our welfare results is that personalized pricing does not affect the total switching costs. This conclusion relies on the uniform distribution of consumers, and the analysis of welfare implications of personalized pricing would be much more complex, and less transparent, for general distributions regarding the period-specific consumer preferences.

Throughout this study we have assumed that there are no direct costs of implementing one or the other pricing regime, in particular no costs of implementing a system with personalized prices. Information acquisition is endogenous and requires no explicit investments other than low prices to attract consumers whose characteristics will be revealed. The striking feature with this mechanism for information acquisition is that the discounted inter-temporal profits are invariant to the pricing system: the investments in information acquisition are not dissipated, but nevertheless these directly benefit consumers by inducing lower introductory offers. It would be an interesting challenge for

future research to study how the conclusions would be altered if information acquisition also required direct investments which are dissipated. Under such circumstances, one could ask: How will the equilibrium configuration with respect to the pricing system depend on potential asymmetries between the firms' effectiveness in information acquisition?

Another feature of interest would be to study the potential effects of differences in discount factors and the horizon between firms and consumers and potentially also between consumer types. We conjecture that our conclusions would not be much altered by such differences, because we have assumed that the firms' products are experience goods and consumers only learn their generic preference by consuming the good. Similar conclusions would hold even for naïve consumers who fail to fully foresee the second period pricing structure, as long as the consumers nevertheless correctly anticipate some symmetry in the second-period prices between the firms.

Appendix

Proof of Result 3:

The integrals in the component capturing total transportation costs can be simplified by exploiting the fact that $t \int_0^x x dx = \frac{t}{2} x^2$ and $t \int_x^1 (1-x) dx = \frac{t}{2} (1-x)^2$. This features facilitates for us to write (30) according to

$$W_2^m = 2x_2^{m,H} \left(v^H - \frac{t}{2} (1-x_2^{m,H}) \right) + 2x_2^{m,L} \left(v^L - \frac{t}{2} (1-x_2^{m,L}) \right) + 2(1-x_2^{m,L}) \left(v^H - s - \frac{t}{2} (1-x_2^{m,L}) \right) + 2(1-x_2^{m,H}) \left(v^L - s - \frac{t}{2} (1-x_2^{m,H}) \right). \quad (A1)$$

In light of (11) we can write $x_2^{NR,H} = a + b_{NR}$ and $x_2^{NR,L} = a - b_{NR}$ by defining $a = \frac{t}{2} + \frac{s}{6t}$ and

$b_{NR} = \frac{\Delta}{2t}$. Likewise, with a unchanged and $b_R = \frac{\Delta}{4t}$, in light of (25) we have that

$x_2^{R,H} = a + b_R$ and $x_2^{R,L} = a - b_R$. Thus, with this notation (A1) can be rewritten according to

$$\begin{aligned}
W_2^m &= 2(a+b_m)(v^H - v^L + s + \frac{t}{2}) - 2t(a+b_m)^2 + 2(v^L - s - \frac{t}{2}) + t(a+b_m) + \\
&2(a-b_m)(v^L - v^H + s + \frac{t}{2}) - 2t(a-b_m)^2 + 2(v^H - s - \frac{t}{2}) + t(a-b_m) = \quad . \\
&4as + 4b_m(v^H - v^L) - 4t(a^2 + (b_m)^2) + 2(v^H + v^L + 2s - t) + 4ta
\end{aligned}$$

Remembering that $b_{NR} = \frac{\Delta}{2t}$ and $b_R = \frac{\Delta}{4t}$ we can now forming the difference

$$W_2^{NR} - W_2^R = 4b_{NR} [v^H - v^L - tb_{NR}] - 4b_R [v^H - v^L - tb_R] = \frac{\Delta^2}{2t}.$$

In order to evaluate this difference in total welfare from the perspective of period 1 we have to multiply by the discount factor, which verifies the conclusion drawn in Result 3.

QED

References

Acquisti, A. and H. Varian. 2005. "Conditioning Prices on Purchase History." *Marketing Science* 24: 367-381.

Brill, J. 2011. "The Intersection of Consumer Protection and Competition in the New World of Privacy." *Competition Policy International* 7: 7-23.

Casadesus-Masanell, R. and A. Hervas-Drane. 2015. "Competing with Privacy." *Management Science* 61: 229-246.

Chen, Y. 1997. "Paying Customers to Switch." *Journal of Economics & Management Strategy* 6: 877-897.

Chen, Y., C. Narasimhan and J. Zhang. 2001. "Individual Marketing with Imperfect Targetability." *Marketing Science* 20: 23-41.

Conitzer, V., C. Taylor, and L. Wagman. 2012. "Hide and Seek: Costly Consumer Privacy in a Market with Repeat Purchases." *Marketing Science* 31: 277-292.

Esteves, R.-B. 2009. "A Survey on the Economics of Behaviour-Based Price Discrimination." NIPE Working Paper 5/2009.

Esteves, R.-B. 2010. "Pricing with Customer Recognition." *International Journal of Industrial Organization* 28: 669-681.

Esteves, R.-B. 2014. "Price Discrimination with Private and Imperfect Information." *The Scandinavian Journal of Economics* 116: 766-796.

FTC. 2012. "Protecting Consumer Privacy in an Era of Rapid Change: Recommendations for Businesses and Policymakers." Federal Trade Commission Report, March, available from www.ftc.gov/os/2012/03/120326privacyreport.pdf

Fudenberg. D. and J. Tirole. 2000. "Customer Poaching and Brand Switching." *RAND Journal of Economics* 31: 634-657.

Fudenberg. D. and M. Villas-Boas. 2007. "Behavior-Based Price Discrimination and Customer Recognition." In *Handbook of Economics and Information Systems*, edited by T. Hendershott. Elsevier, 377-433.

Gehrig, T. and R. Stenbacka 2004: "Differentiation-Induced Switching Costs and Poaching." *Journal of Economics & Management Strategy* 13: 635-655.

Hermalin, B. and M. Katz. 2006. "Privacy, Property Rights and Efficiency: The Economics of Privacy as Secrecy." *Quantitative Marketing and Economics* 4: 209-239.

Jentzsch, N., G. Sapi, and I. Suleymanova. 2013. "Targeted Pricing and Customer Data Sharing Among Rivals." *International Journal of Industrial Organization* 31: 131-144.

Klemperer, P. 1987a. "The Competitiveness of Markets with Switching Costs." *The RAND Journal of Economics* 18: 138-150.

Klemperer, P. 1987b. "Markets with Consumer Switching Costs." *Quarterly Journal of Economics* 102: 375-394.

Liu, Q. and K. Serfes. 2004. "Quality of Information and Oligopolistic Price Competition." *Journal of Economics & Management Strategy* 13: 671-702.

Posner, R. 1978. "The Right of Privacy." *Georgia Law Review* 12: 393-422.

Posner, R. 1981. "The Economics of Privacy." *American Economic Review* 71: 405-409.

Shy, O. and R. Stenbacka. 2013. "Investment in Customer Recognition and Information Exchange." *Information Economics and Policy* 25: 92-106.

Shy, O. and R. Stenbacka. 2014. "Customer Privacy and Competition." Hanken School of Economics, working paper.

Stigler, G. 1980. "Introduction to Privacy in Economics and Politics." *Journal of Legal Studies* 9: 623-644.

Taylor, C. 2004. "Customer Privacy and the Market for Customer Information." *RAND Journal of Economics* 35: 631-650.

Taylor, C. and L. Wagman. 2014. "Customer Privacy in Oligopolistic Markets: Winners, Losers, and Welfare." *International Journal of Industrial Organization* 34: 80-84.

Tucker, C. 2012. "The Economics of Advertising and Privacy." *International Journal of Industrial Organization* 30: 326-329.

Villas-Boas, M. 2014. "A Short Survey on Switching Costs and Dynamic Competition." University of California, Berkeley, working paper.

Von Weizsäcker, C. C. 1984. "The Costs of Substitution." *Econometrica* 52: 1085-1116.