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products and switching costs**

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Customer poaching with differentiated products and switching costs

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Abstract

We consider a dynamic two-period model where two firms offer products that are differentiated a la Hotelling. Consumers purchase products in a first period, and in a second period consumers are locked-in to their first-period choice of producer with a switching cost. In the second period firms are able to price discriminate based on consumers purchase history from period 1. We show that i) firms will approach their rival's customers by low prices in the second period (customer poaching) and that inefficient switching will occur, ii) second-period prices are dependent on first-period market shares, a result in contrast to some of the received literature. Finally, iii) with high enough switching costs first-period prices is below the level in a static setting, and more so the higher the switching costs and the more differentiated the products are.

1 Introduction

If firms can observe past behavior of potential customers and arbitrage is infeasible among customers firms may price discriminate based on purchase history. For instance, if a firm can observe whether a potential customer was a previous customer of his firm or a rival, firms may offer discounts to new customers to make these customers switch. Examples of such price discrimination are abundant. For instance, in the Telecom industry Schwarz (1997) reports that 20% of all US household switched long-distance provider in 1994 and in the years that followed many providers offered one-time bonuses to the switchers.

Received literature on this topic has analyzed this issue in specific models of imperfect competition. The two most commonly used models are Hotelling models of product differentiation (Villas-Boas (1999)¹ and Fudenberg and Tirole (2000)) and models with switching costs (Chen (1997) and Taylor (1999)). The results from this literature will be reviewed in more detail below, but already at this point it is noteworthy that the results are heavily dependent on the assumptions made regarding the underlying competitive mode between firms. Chen (1997) and Fudenberg and Tirole (2000) use two-period models where firms acquire customers in a first period and the

¹See also Villas-Boas (2001).

in second period firms may observe whether potential customers previously bought from them or the rival firm. Villas-Boas (1999) has infinitely lived firms with overlapping generations of consumers, and Taylor (1999) has a multiperiod model where a consumer's switching cost vary from period to period. In all articles firms can recognize customers and can price discriminate by offering previous customers of the rival firms lower prices than own previous customers.

In Fudenberg and Tirole (2000) firms are differentiated a la Hotelling and a central result is that first-period prices are higher than in the corresponding static model. In Chen (1997) products are ex ante homogeneous, but becomes ex post differentiated due to switching costs. In contrast to the findings of Fudenberg and Tirole (2000) first-period prices in Chen (1997) are lower than in the corresponding static model. Hence, predictions rely heavily on the specific modelling of imperfect competition. A central aim with the present paper is bridge some of the gap between these two approaches by building a model with differentiated products (in a Hotelling style model) and where consumers also must incur switching costs in the second period.

Before we present our results it may be worthwhile to examine in somewhat more detail the assumptions and results from the received literature. Fudenberg and Tirole (2000) have a duopoly where firms are located on each endpoint of a Hotelling line. Firms compete in two periods with no switching

costs in the second period. The results are that firms price discriminate in the second period and a positive fraction of consumers do switch (customer poaching). The switching is socially wasteful since some of the consumers switches from their preferred brand to a less preferred one in the second period. Since consumers realize that they will be approached by a rival with discounts in the second period, first-period demand becomes less elastic. This tends to raise first-period prices so as to make the equilibrium first-period prices higher than in the static model. Hence, the ability to price discriminate is beneficial for the firms. Villas-Boas (1999) also studies a linear city duopoly with customer recognition, but he assumes that firms are infinitely lived while demand is derived from overlapping generations of consumers who live for two periods.

Chen (1997) uses a homogeneous good model where products become ex post differentiated by a uniformly distributed switching cost. Firms compete in two periods where first the firms set prices and consumers chooses which product to buy. Then, in the beginning of the second period, consumers learn their switching costs and firms offer prices to own customers and poaching prices. Some customers will switch in equilibrium, and due to the switching costs this switching is also socially wasteful. Moreover, as is usual in models with switching costs (see Klemperer (1995) for an overview over the switching

costs literature²) first-period prices are lower than in the corresponding static model. In Chen's model first-period prices are in fact lower than marginal costs. The reason is that firms compete harshly for customers that they will exploit in the second period when they are locked-in. Taylor (1999) extends Chen's model in several ways. Taylor (1999) considers a multiperiod model where firms produce homogeneous products and consumers incur switching costs, but where switching costs may vary from period to period.

Of particular interest in Chen (1997) is how a firm's market share affects its pricing behavior. This issue is interesting "... not only because it sheds light on price competition in a mature market where each firm has established a market share, but also because it can have implications for consumer demand and the price competition in a new market..." (Chen (1997), p 878). A central finding in Chen (1997) is that the equilibrium second-period prices of the firms are independent of first-period market shares. A similar result is also obtained by Taylor (1999). In this paper we show that the independence result found in the received literature is not robust to introducing product differentiation into a model with switching costs. By introducing only a small amount of (ex ante) product differentiation in addition to switching costs, the independence result evaporates.

The model we use is one where firms are located at each end of a Hotelling

²See also Nilssen (1992) and Wang and Wen (1998).

line and where consumers who bought from one firm in the first period must incur switching costs if they wish to switch to the second firm in period two. Firms choose prices in period one and customers choose where to buy. Given this, firms offer second-period prices where they can price discriminate between consumers based on purchase history. As in Fudenberg and Tirole (2000) and Chen (1997) a positive fraction of consumers switches in equilibrium. This switching is socially wasteful for two reasons: First, some consumers switch to their least preferred brand in the second-period, and second they incur switching costs.

In contrast to the finding in Chen (1997), we show that second-period (the mature market) prices now depend on first-period market shares. Prices to own customers are increasing in market share, but poaching prices are inversely related to market shares. That prices to own customers is increasing in market share is what we should expect, but as noted above, it contradicts the independence result found in Chen (1997) and also in Taylor (1999). More surprising is the fact that poaching prices are inversely related to market shares, i.e. a firm with a high market share in the mature market will offer huge discounts to new customers. The intuition is that with product differentiation a firm with a large market share must try to attract customers with strong underlying preferences for the rival brand. The larger a market share a firm has, the larger is the average brand preference of the rival firm's

customers for this firm's brand. Hence, poaching prices is decreasing in a firm's market share.

When switching costs in our model are high enough relative to the brand preferences of the consumers, first-period prices exhibit the well-known features of switching costs models, i.e. they are lower than the static prices. However, in the present model this result is not trivial as Fudenberg and Tirole (2000) found that absent switching costs first-period prices is indeed higher than the static prices. Product differentiation tends to push first-period prices up, and switching costs tend to push first-period prices down. When switching costs are high enough, the latter effect dominates.

The rest of the article is organized as follows. Section 2 presents the basic features of our model and briefly reviews the result from the static linear city model. The main section, Section 3, solves the dynamic model with switching costs in a linear city. Section 4 concludes and points at some directions for further research.

2 The model

There are two firms denoted by $i = A, B$ that are differentiated in a Hotelling sense. Each firm is located at each end of the unit interval and consumers are uniformly distributed along the interval. Firm A is located at $x = 0$ and

firm B is located at $x = 1$. Firms have constant marginal production costs equal to c .

Consumers have unit demand and derives gross utility v from consumption of the good, and incur a linear transportation cost t per unit of distance. Throughout the paper we will assume that v is sufficiently large so that all consumers will buy. Hence, a consumer located in address x incurs transportation costs tx if buying from firm A and $t(1 - x)$ if buying the good of firm B .

There are two periods. In period 1 firms A and B announce prices a and b , respectively, and consumers choose where to buy. Consumers get locked-in to their first-period supplier with a switching cost s that is uniformly distributed on $[0, \theta]$. The distribution of switching costs is independent of consumers' distribution on the unit interval.

In the second-period we will assume that firms are able to identify customers based on their purchase record in period 1. Alternatively, one could also assume that second-period customers are all anonymous to the producers, but this case is not considered here. With customer recognition firms can price discriminate between customers that previously bought their product and customers of the rival firm. By lowering the price to 'new' customers, firms may be able to poach some share of the rival's customers.

Therefore, with customers recognition each firm A and B offer prices α

and β to customers that bought from them in period 1, and prices α_2 and β_2 to customers that bought from the rival firm in period one ('poaching prices'). Thus, α_2 is the price offered by firm A to the customers that bought from firm B in period 1, and β_2 is the price offered by firm B to the consumers that bought product A in period 1. All firms and consumers use a common discount rate of δ .

As a point of reference we first briefly review the standard solution to the static Hotelling model without switching costs, i.e. the case when there are no second period. When firms offer prices a and b the marginal consumer located in x is characterized by:

$$v - tx - a = v - t(1 - x) - b$$

$$\Downarrow$$

$$x = \frac{1}{2} \frac{b - a + t}{t}$$

Firms A and B maximize

$$\max_a (a - c)x$$

$$\max_b (b - c)(1 - x)$$

which yield the following two first-order conditions

$$\frac{1}{2} \frac{b-2a+t+c}{t} = 0$$

$$\frac{1}{2} \frac{t-2b+a+c}{t} = 0$$

and by solving these we have:

Proposition 1 *In the static model without switching costs the equilibrium prices are $a = b = c + t$.*

With symmetric prices, firms split the market in half. When t approaches zero, the market approaches a market with homogeneous products and the well-known Bertrand paradox appears with marginal cost pricing. Let us now focus on the more interesting part, namely the dynamic model where products are differentiated and customers learn their switching costs in the beginning of the second period.

3 The dynamic model

The dynamic model is solved by investigating the second-period pricing problem for the two producers given their inherited market shares from the first period, and then solving the first-period pricing problem. Let k be the inherited market share for firm A from period 1 and $1 - k$ the equivalent for firm B .

3.1 Second-period poaching

When customers can be recognized, firms may price discriminate between own and new customers. Let q_{ij} denote the share of consumers who bought from firm j previously but buy from firm i in the second period. A consumer who bought from firm A in the first period will be indifferent between continuing to do so and switching to buying from firm B if her switching cost is such that

$$v - tx - \alpha = v - t(1 - x) - \beta_2 - s_A$$

$$\Updownarrow$$

$$s_A(x) = t(2x - 1) + (\alpha - \beta_2)$$

Similarly, a consumer who bought from firm B in the first period will be indifferent between continuing to do so and switching to buying from firm A if her switching cost is such that

$$v - t(1 - x) - \beta = v - tx - \alpha_2 - s_B$$

$$\Updownarrow$$

$$s_B(x) = t(1 - 2x) + \beta - \alpha_2$$

The function $s_A(x)$ is increasing in x and $s_B(x)$ is decreasing in x , and

both functions are linear in x . Depending on the prices α, β, α_2 and β_2 and x we may have different cases. We will work with the simplest case where $s_A(0) \geq 0, s_B(1) \geq 0$ and $s_i(k) \leq \theta$. For now, assume that all three inequalities hold.³

In this case we can compute the share of A 's previous customers that continues to buy from A , i.e. the share q_{AA} , in the following way:

$$\begin{aligned} q_{AA} &= \int_0^k \left(\int_{t(2x-1)+(\alpha-\beta_2)}^{\theta} \frac{1}{\theta} ds \right) \frac{1}{x} dx \\ &= \int_0^k \frac{1}{\theta} (\theta - 2tx - \alpha + t + \beta_2) dx \\ &= \frac{k}{\theta} (\theta + t(1-k) - (\alpha - \beta_2)) \end{aligned}$$

Then we can find the share of A 's previous customers that switches to B in the second period as $q_{BA} = k - q_{AA}$

$$\begin{aligned} q_{BA} &= k - \left(\frac{k}{\theta} (\theta + t(1-k) - (\alpha - \beta_2)) \right) \\ &= \frac{k}{\theta} (tk + \alpha - t - \beta_2) \end{aligned}$$

³This will of course be checked in our optimal solution.

Similarly, the fraction q_{BB} is given by

$$\begin{aligned} q_{BB} &= \int_k^1 \left(\int_{t(1-2x)+(\beta-\alpha_2)}^\theta \frac{1}{\theta} ds \right) dx \\ &= 1 - k - \frac{(1-k)(\beta - tk - \alpha_2)}{\theta} \end{aligned}$$

and then the fraction that leaves firm B to firm A is given by

$$\begin{aligned} q_{AB} &= (1 - k) - \left(1 - k - \frac{(1-k)(\beta - tk - \alpha_2)}{\theta} \right) \\ &= \frac{(1-k)(\beta - tk - \alpha_2)}{\theta} \end{aligned}$$

Now the overall second period profits for the firms π_{2i} are given by

$$\begin{aligned} \pi_{2A} &= (\alpha - c)q_{AA} + (\alpha_2 - c)q_{AB} \\ \pi_{2B} &= (\beta - c)q_{BB} + (\beta_2 - c)q_{BA} \end{aligned}$$

Firm A earns profit in the second period from the customers that stay with firm A in both period and the customers that switch from firm B in the second period. Similarly, firm B earns profit from the stayers and the switchers from firm A . When inserting for the demands above we have:

$$\begin{aligned}
\pi_{2A} &= (\alpha - c) \left(\frac{k}{\theta} (\theta + t(1 - k) - (\alpha - \beta_2)) \right) \\
&\quad + (\alpha_2 - c) \left(\frac{(1 - k)(\beta - tk - \alpha_2)}{\theta} \right) \\
\pi_{2B} &= (\beta - c) \left(1 - k - \frac{(1 - k)(\beta - tk - \alpha_2)}{\theta} \right) \\
&\quad + (\beta_2 - c) \left(\frac{k}{\theta} (tk + \alpha - t - \beta_2) \right)
\end{aligned}$$

Maximizing these profit expression with respect to prices α and α_2 for firm A and β and β_2 for firm B yields the following result

Proposition 2 *Given a market share k from period 1 for firm A and $(1 - k)$ for firm B the second-period prices α and β and the poaching prices α_2 and β_2 are given by*

$$\begin{aligned}
\alpha(k) &= c + \frac{1}{3}t(1 - k) + \frac{2}{3}\theta \\
\alpha_2(k) &= c - \frac{1}{3}tk + \frac{1}{3}\theta \\
\beta(k) &= c + \frac{1}{3}tk + \frac{2}{3}\theta \\
\beta_2(k) &= c - \frac{1}{3}t(1 - k) + \frac{1}{3}\theta
\end{aligned}$$

Proof. Maximizing the second period profits yields the following first-

order conditions

$$\begin{aligned}
-k \frac{tk - \theta - t + 2\alpha - \beta_2 - c}{\theta} &= 0 \\
-\frac{-tk^2 + tk - \beta + \beta k + 2\alpha_2 - 2\alpha_2 k - c + ck}{\theta} &= 0 \\
\frac{-tk^2 + tk - 2\beta + 2\beta k + \alpha_2 - \alpha_2 k + \theta - k\theta + c - ck}{\theta} &= 0 \\
k \frac{tk - t + \alpha - 2\beta_2 + c}{\theta} &= 0
\end{aligned}$$

and solving these yields the prices in the proposition. ■

In contrast to Chen (1997) we now see that second-period prices depend on first-period market share. A central finding in Chen (1997) is that equilibrium prices in the mature market (the second period) of both firms are independent of their respective market shares. The latter is true in Chen's model only when firms can price discriminate between own and the rival's customers.⁴ When firms cannot price discriminate and must offer all customers the same prices in the mature market, Chen (1997) shows that higher market shares will indeed raise prices. From our model where we have both price discrimination and switching costs we see that the result of market share dependent prices is restored also in the case where firms can price discriminate in the mature market.

The prices obtained by Chen (1997) can be obtained here by setting $t = 0$.

⁴Chen (2000) denotes this as PCTS, short for 'Paying customers to switch'. Alternatively, firms are unable to price discriminate in the mature market, a case denoted as UNIF.

With homogeneous products and switching costs, second-period prices are independent of first-period market share (the independence result). When $t > 0$ for either firm, a higher market share from period 1 will increase his price to own customers and lower his poaching price. The intuition is that the transportation costs adds to the switching costs born by the customers and therefore make them less reluctant to switch. Consequently, the locked-in customers may be exploited more and the rival firm's customers must be offered a lower poaching price to induce switching. The higher market share a firm has from period 1, the stronger these effects are.

One may therefore wonder what the exact reason is for the differences in results in our model and Chen (1997). As noted by Chen (1997) his independence result is somewhat surprising. Normally, under the existence of switching costs large firms tends to exploit locked-in consumers more than smaller firms. This is exactly what is happening in our model, a firm with a larger inherited market share from the first period, will set a high price to its locked-in customers. Hence, the independence result in Chen (1997) is not very general. Moreover, the firms' poaching prices are decreasing in market shares. The higher market share a firm has, the lower price it offers to the rival firm's customers. The intuition is the following: The higher market share a firm has, the more likely it is that the rival firm will have acquired customers from period that have strong underlying preferences for

that product. To put it differently, the higher market share firm A has, the higher will the average transportation cost of firm B's customers be to firm A's location. In order to attract these customers firm A must therefore lower its poaching price, and more so the higher A's market share.

By inserting optimal second-period prices into second-period profits we have:

$$\pi_{2A}(k) = \frac{1}{9} \frac{-t^2 k^2 - 2tk^2\theta + t^2 k + 2tk\theta + 3k\theta^2 + \theta^2}{\theta}$$

$$\pi_{2B}(k) = -\frac{1}{9} \frac{-2tk\theta + 2tk^2\theta + t^2 k^2 - 4\theta^2 + 3k\theta^2 - t^2 k}{\theta}$$

We now turn to the first-period pricing problem where firms set prices anticipating the consequences for the second-period outcome.

3.2 First-period pricing

As noted above A 's first period price is a and B 's is b . If first-period prices lead to a cutoff $k^* \in (0, 1)$ we must have that type k^* is indifferent between buying good A in period 1 at a and then buying B in period 2 at the poaching price β_2 , or buying B in period 1 at price b and then buying A at the poaching price α_2 . In other words, type k^* is defined by

$$v - tk^* - a + \delta(v - t(1 - k^*) - s - \beta_2) = v - t(1 - k^*) - b + \delta(v - tk^* - s - \alpha_2)$$

and solving this with respect to k^* yields

$$k^* = \frac{1}{2} \left(\frac{b - a + \delta(\alpha_2 - \beta_2)}{t(1 - \delta)} + 1 \right)$$

However, as shown in Proposition 2 the second-period poaching prices are also functions of first-period market shares. Inserting the optimal second-period poaching prices from Proposition 2 in the expression for k^* above and then solving for k gives the cutoff market share in period one as function of first-period prices only $k^*(a, b)$

$$k^*(a, b) = \frac{1}{2} \left(\frac{3(b - a)}{t(3 - 2\delta)} + 1 \right) \quad (1)$$

Firm A 's overall maximization problem then becomes:

$$\max_a \Pi_A = \max_a (a - c)k^*(a, b) + \delta\pi_{2A}(k^*(a, b))$$

and for firm B

$$\max_b \Pi_B = \max_b (b - c)(1 - k^*(a, b)) + \delta\pi_{2B}(k^*(a, b))$$

Solving the two maximization problems above and solving for the equilibrium prices yields the following result:

Proposition 3 For $\theta \geq 2t$, $k^* = \frac{1}{2}$ and

$$a = c + t - \frac{1}{3}\delta(\theta + 2t)$$

$$b = c + t - \frac{1}{3}\delta(\theta + 2t)$$

and

$$\alpha = \beta = c + \frac{2}{3}\theta + \frac{1}{6}t$$

$$\alpha_2 = \beta_2 = c + \frac{1}{3}\theta - \frac{1}{6}t$$

constitute a subgame perfect equilibrium.

Proof. The first-order conditions for the intertemporal pricing problem are

$$\frac{\frac{1}{2} \frac{9\theta b - 4\theta b\delta - 18\theta a + 10\theta a\delta + 9t\theta - 12\theta\delta t + 4\theta\delta^2 t + 9\theta c - 6\theta\delta c + b\delta t - a\delta t - 3\theta^2\delta + 2\theta^2\delta^2}{t(-3+2\delta)^2\theta}}{2} = 0$$

$$\frac{\frac{1}{2} \frac{9t\theta - 12\theta\delta t + 4\theta\delta^2 t - 18\theta b + 10\theta b\delta + 9\theta a - 4\theta a\delta + 9\theta c - 6\theta\delta c - b\delta t + a\delta t - 3\theta^2\delta + 2\theta^2\delta^2}{t(-3+2\delta)^2\theta}}{2} = 0$$

and solving these yields

$$a = c + t - \frac{1}{3}\delta(\theta + 2t)$$

$$b = c + t - \frac{1}{3}\delta(\theta + 2t)$$

By straight forward insertion in the expression for $k^*(a, b)$ we get

$$k^*(a, b) = \frac{1}{2} \left(\frac{3(b-a)}{t(3-2\delta)} + 1 \right) = \frac{1}{2}$$

and

$$\begin{aligned} \alpha = \beta &= c + \frac{2}{3}\theta + \frac{1}{6}t \\ \alpha_2 = \beta_2 &= c + \frac{1}{3}\theta - \frac{1}{6}t \end{aligned}$$

Finally we must check that we are in the relevant case, i.e. $s_A(0) \geq 0$, $s_B(1) \geq 0$ and $s_i(\frac{1}{2}) \leq \theta$. Inserting the equilibrium prices yields

$$s_A(0) = t(2x - 1) + (\alpha - \beta_2) \geq 0 \iff 2t \leq \theta$$

$$s_B(1) = t(1 - 2x) + \beta - \alpha_2 \geq 0 \iff 2t \leq \theta$$

$$s_A(\frac{1}{2}) \leq \theta \iff \frac{1}{2}t \leq \theta$$

$$s_B(\frac{1}{2}) \leq \theta \iff \frac{1}{2}t \leq \theta$$

Hence, $\theta \geq 2t$ is a necessary and sufficient condition for being in our case. ■

We see that first-period prices are below the prices in the static model, and that both switching costs and product differentiation contribute to this fact. The more product differentiation and the higher switching costs, the

more first-period prices are below the prices in the static model. Also, we observe that for $t = 0$ (homogeneous products) we are back in Chen (1997) model. Note, however, that our results cannot be directly compared with Fudenberg and Tirole (2000) who has $\theta = 0$. The reason is that our results so far are only valid for sufficiently high switching costs ($\theta \geq 2t$).

It is however interesting to note that when switching costs are high enough more product differentiation (higher t) tends to lower first-period prices in a similar way that higher switching costs do. In some sense more differentiation adds to switching costs in the second period. This is in contrast to Fudenberg and Tirole (2000) who found that absent switching costs, more differentiation (higher transportation costs) tends to increase first-period prices. The effects from higher transportation and higher switching costs on the poaching prices are however opposite. Intuitively, higher transportation costs tend to lower poaching prices. The reason is that with higher transportation costs customers become more attached to their preferred brand and must be offered a lower price to switch. Here switching costs works the opposite way; more switching costs tend to increase the poaching prices. This may at first sight seem very surprising. Note however that the prices offered to own customers increases faster than the poaching prices when switching costs increase, hence the discount offered to the rival firm's customers actually increase when switching costs increase. This result is in line with the findings

in Chen (1997).

4 Concluding remarks

Price discrimination based on customer recognition has received scarce attention in economic literature. The last few years some important contributions have emerged, but this is still an area of research with significant potential. In going through the relatively scarce literature on this topic we have pointed at some of the perceived problems. First of all it is noted that for price discrimination to be feasible, firms need to identify different consumers with different demand elasticities. In this literature the ability to recognize customers based on previous purchases has been the key element in this respect. Two main avenues have been pursued. The first one is that consumers may have heterogeneous preferences, and that once these preferences are revealed firms can approach customers that have revealed weak preferences for their product with lower prices. The second avenue is that firms are *ex ante* identical for consumers, but become *ex post* differentiated due to switching costs once consumers have purchased one of the products.

We have shown that these two approaches lead to very different predictions with respect to how the equilibrium price structure would look like, and what the implications are for firms and consumers. This paper is the

first attempt that we are aware of that aims at bridging some of the gap between the two approaches by explicitly taking into account both the possibility of heterogeneous preferences and the possibility that there may be costs involved for the consumers by switching between different suppliers.

By doing this we are able to gain some important new insights on how the different forces work in determining the equilibrium price structure and the profitability of this type of price discrimination. This enables us to make testable predictions on how the price structure should depend on factors such as differentiation, the degree of switching costs and firm size in mature markets. Still, we would like to stress this article only constitute one modest step in achieving this goal, and that there are still many avenues to pursue.

We have conducted the analysis assuming that switching costs are sufficiently high relative to the differentiation of the products offered by the two producers. The main argument for doing this is that our model is well behaved under this assumption. Of course it would also be interesting to analyze the case with low switching costs. In this case we conjecture that our results would resemble more and more the ones obtained by Fudenberg and Tirole (2000). However, a formal analysis of this issue is left for future research.

Also, it would be interesting to analyze the case of anonymous consumers in the second period in our model. If so, second-period price discrimination

would be infeasible and all customers would have to be offered the same prices. However, with both product differentiation and switching costs our model becomes fairly intractable, but it should in principle be possible to solve our model under this assumption. We are currently working along these lines and hopefully the results from this case will appear in the near future.

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