

# Dynamic Price Discrimination With Asymmetric Firms

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## 1. Introduction

- Price discrimination based on consumers' past purchases:
  - A long-distance telephone company offers a lower price to customers who switch from a competitor's service;
  - A credit card company offers a lower interest rate to consumers who transfer balances from competitors;
  - An electricity company offers lower rates to a rival's customers.
- Common features in these examples of dynamic price discrimination:
  - Prices depend on consumers' past purchase behavior, and incorporate explicit dynamic considerations.
  - The information about a consumer's purchase history takes a particularly simple form, namely whether the consumer is a rival's customer.
- The economics literature has focused on markets with a fixed number of ex ante symmetric firms (e.g., Chen, 1997; Villas-Boas, 1999; Fudenberg and Tirole, 2000; and Taylor, 2003). A common theme is that dynamic price discrimination tends to intensify competition and reduce prices.

- In some recent antitrust cases, the issue of dynamic price discrimination has arisen in markets with asymmetric firms.
- *AKZO Chemie BV v Commission*
  - AKZO was a company with a dominant market position of the flour additives market in UK and Ireland (with 55% of market share in 1984).
  - Beginning in 1979, it pursued a discriminating pricing strategy that offered prices to the customers of a smaller competitor, ECS , that were substantially lower than prices it offered to its own customers.
  - The European Court of Justice concluded that AKZO's intention was not to pursue a general policy of favorable prices, but to adopt a strategy that could damage ECS; and as such, AKZO's pricing behavior was abusive.
- In 2005 the Swedish Competition Authority sued Teliasonera, a dominant firm in the Swedish telecom market, for having selectively offered better terms to a rival's customers. The agency alleges that the company has abused its dominant market position by engaging in the discriminating practices.

- These cases suggest a view by antitrust authorities that dynamic price discrimination in some asymmetric markets are anticompetitive and harmful to consumers, in contrast to the results from the existing economics literature.
- Therefore, there is a need to extend the economics literature on dynamic price discrimination to markets with asymmetric firms, for the interests in both economic theory and antitrust analysis.
- This paper provides an economic analysis of dynamic price discrimination with asymmetric firms.
- We consider variants of a dynamic duopoly, where one of the firms has a stronger market position.
  - The basic model
  - An extended model with increased competition
  - An extended model with consumer switching costs

## 2. The Basic Model

- Time is discrete and is indexed as  $1, 2, \dots, T$ , where  $T \geq 3$ . The discount factor for all players is  $\delta$ .
- Two firms,  $A$  and  $B$ , with constant marginal costs  $c_A \geq c_B$ . Firm  $B$  has a fixed cost  $k$  to stay in the market for each of the periods  $t \geq 3$ .
- Two types of consumers,  $H$  and  $L$ . Their sizes are  $\alpha$  and  $1 - \alpha$ , respectively. A consumer's type is her private information.
  - Each type  $H$  consumer demands one unit of the product with reservation price  $V_H$ , and will only purchase from  $A$ .
  - Each type  $L$  consumer will purchase  $q = G(p)$  from any firm with the lower price,  $p$ , where

$$G(p) \begin{cases} > 0 & \text{if } p < V_H \\ = 0 & \text{if } p \geq V_H \end{cases}, \text{ and surplus } s(p).$$

- This formulation captures a market where consumers have different brand preferences and one firm possesses a stronger brand. Vertical- and horizontal-differentiation interpretations of the model.

- Define, for  $j = A, B$ ,

$$\begin{aligned}\pi_j(p) &= (p - c_j) G(p), \\ p_j^m &= \arg \max_p \pi_j(p).\end{aligned}$$

Then  $p_j^m$  and  $\pi_j(p_j^m)$  would be firm  $j$ 's monopoly price and profit with respect to  $L$  consumers, and  $p_j^m < V_H$ .

- Assumption A1: For  $j = A, B$ ,  $p_j^m$  exists uniquely,  $c_A < p_B^m \leq p_A^m$ ,  $\pi_j'(p) > 0$  for  $p < p_j^m$ , and  $k \leq (1 - \alpha) \pi_B(p_B^m)$ .

- For the basic model, we further assume

$$(p_B^m - c_A) [\alpha + (1 - \alpha) G(p_B^m)] < \alpha (V_H - c_A). \quad (\text{C1})$$

- Under uniform price, or *UP*, each firm can only set a single price at each period. The basic model has a unique perfect equilibrium under *UP*.
- At this equilibrium,  $\{p_{tA}^{u*}, p_{tB}^{u*}\} = \{V_H, p_B^m\}$  for  $t = 1, \dots, T$ , and  $H$  and  $L$  consumers purchase from  $A$  and  $B$ , respectively, for all  $t$ ,

- Under discriminating price, or *DP*, firms can offer different prices to consumers who have different purchasing histories.
- At the beginning of some  $t \geq 2$ ,  $\beta_{tA}$  consumers have only purchased from *A* in the past,  $\beta_{tB}$  consumers have purchased from *B* in the past, and  $1 - \beta_{tA} - \beta_{tB}$  have not made purchase in the past. Call them consumers with purchase history *a*, *b*, and *o*, respectively.
- Under *DP*, firm *A* and *B* each can offer *up to* three different prices at every  $t \geq 2$  to these three groups of consumers:

$$(p_{tA}^a, p_{tA}^b, p_{tA}^o) \text{ and } (p_{tB}^a, p_{tB}^b, p_{tB}^o).$$

- Let  $(\mu_{tj}^a, \mu_{tj}^b, \mu_{tj}^o)$  denote the belief of firm  $j \in \{A, B\}$  at  $t$ , the probability that  $j$  assigns to group  $i \in \{a, b, o\}$  of being type *H*.
- At a perfect Bayesian equilibrium (PBE), the strategies of all players are sequentially rational given the belief system, and the beliefs are consistent with players' strategies and with the Bayes' rule wherever possible.

**Proposition 1.** (i) If  $(1 - \alpha) \pi_B (c_A) \geq k$ , the basic model has a unique PBE under *DP*. At this equilibrium, *B* stays in the market for all periods,

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{tA}^{a*}, p_{tA}^{b*}), p_{tB}^{b*}\} &= \{(V_H, c_A), c_A\} \text{ for } t = 2, \dots, T; \end{aligned}$$

all *H* consumers purchase from *A* and all *L* consumers purchase from *B* in all periods.

(ii) If  $(1 - \alpha) \pi_B (c_A) < k$ , the basic model has a unique PBE under *DP*. At this equilibrium, *B* exits at the end of  $t = 2$ ,

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{2A}^{a*}, p_{2A}^{b*}), p_{2B}^{b*}\} &= \{(V_H, c_A), c_A\}, \\ (p_{tA}^{a*}, p_{tA}^{b*}) &= (V_H, p_A^m) \text{ for } t = 3, \dots, T; \end{aligned}$$

all *H* consumers purchase from *A* and all *L* consumers purchase from *B* in  $t = 1, 2$ , and all consumers purchase from *A* in  $t = 3, \dots, T$ .

- If  $DP$  does not cause  $B$  to exit, then  $L$  consumers receive lower price for  $t \geq 2$ , while the price for  $H$  consumers is  $V_H$ , same as under  $UP$ . Therefore  $DP$  benefits consumers.
- If  $DP$  causes  $B$  to exit, then price goes down in  $t = 2$  but goes up again after  $B$  exits at the end of time 2. If  $c_A > c_B$ , or  $p_A^m > p_B^m$ , then there is a trade off between short-term gain and long-term loss in consumers welfare, and  $DP$  reduces consumer welfare if both  $T$  and  $\delta$  are large.
- Consumer welfare under  $DP$ ,  $W^d$ , is non-monotonic in  $c_A$ . When  $c_A$  starts from some high value such that  $(1 - \alpha) \pi_B(c_A) > k$ , marginal decreases in  $c_A$  increase  $W^d$ . As  $c_A$  goes down further to reach the point at which  $(1 - \alpha) \pi_B(c_A) = k$ , a marginal decrease in  $c_A$  reduces  $W^d$ , due to the exit effect.  $W^d$  rises again as  $c_A$  decreases further.
- Firm  $A$ 's lowest price in equilibrium is  $c_A$ , which is  $A$ 's marginal as well as average (variable) cost. Firm  $A$  does not engage in below-cost pricing, even when its more aggressive pricing under  $DP$  causes  $B$  to exit.

### 3. Increased Competition

- Our basic model has two noteworthy features.
  - First, due to condition (C1), competition is weak, in the sense that under uniform price the firm with a stronger brand relinquishes the low-value consumer segment to the weaker competitor, so that there is no head-to-head competition between the two firms.
  - Second, consumer preferences are constant overtime; namely past purchases do not affect consumer preferences towards either firm.
- We now consider the effects of increased competition by reversing (C1) and instead assuming (C2):

$$(p_B^m - c_A) [\alpha + (1 - \alpha) G(p_B^m)] > \alpha (V_H - c_A). \quad (\text{C2})$$

In this case, let  $\underline{p} \in (c_A, p_B^m]$  be such that

$$(\underline{p} - c_A) (\alpha + (1 - \alpha) G(\underline{p})) = \alpha (V_H - c_A).$$

- Under  $UP$ , there is no pure-strategy equilibrium, but there is a unique mixed-strategy equilibrium, at which  $A$  and  $B$  price according to probability distribution functions  $(F_A(p), F_B(p))$  in each period:

$$F_A(p) = \begin{cases} 1 & \text{if } p \geq V_H \\ 1 - \frac{\pi_B(p)}{\pi_B(p_B^m)} & \text{if } p_B^m \leq p < V_H \\ 1 - \frac{\pi_B(p)}{\pi_B(\underline{p})} & \text{if } \underline{p} \leq p < p_B^m \\ 0 & \text{if } p < \underline{p} \end{cases},$$

$$F_B(p) = \begin{cases} 1 & \text{if } p \geq p_B^m \\ 1 - \frac{\alpha(V_H - p)}{(1 - \alpha)\pi_A(p)} & \text{if } \underline{p} < p < p_B^m \\ 0 & \text{if } p < \underline{p} \end{cases}.$$

- The equilibrium profits per period for  $A$  and  $B$  are

$$\pi_A^* = \alpha (V_H - c_A),$$

$$\pi_B^* = (1 - \alpha) \pi_B(\underline{p}).$$

- The expected equilibrium prices of  $H$  and  $L$  consumers are  $p_H^u < V_H$  and  $p_L^u < p_B^m$ .

- Under *DP*, (i) If  $(1 - \alpha) \pi_B (c_A) \geq k$ , there is a PBE at which  $B$  stays in the market for all periods,

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{tA}^{a*}, p_{tA}^{b*}), p_{tB}^*\} &= \{(V_H, c_A), c_A\} \text{ for } t = 2, \dots, T; \end{aligned}$$

and all  $H$  and  $L$  consumers purchase from  $A$  and  $B$ , respectively, in all periods.

- (ii) If  $(1 - \alpha) \pi_B (c_A) < k$ , there is a PBE under *DP*, at which  $B$  exists at the end of  $t = 2$ ,

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{2A}^{a*}, p_{2A}^{b*}), p_{2B}^*\} &= \{(V_H, c_A), c_A\}, \\ (p_{tA}^*, p_{tA}^{b*}) &= (V_H, p_A^m) \text{ for } t = 3, \dots, T; \end{aligned}$$

all  $H$  and  $L$  consumers purchase from  $A$  and  $B$ , respectively, in  $t = 1, 2$ , and all consumers purchase from  $A$  in  $t = 3, \dots, T$ .

- $DP$  now raises price for the  $H$  consumers.
- If  $DP$  does not cause  $B$  to exit, then it lowers the price for  $L$  consumers in all periods except period 1. A sufficient condition for  $DP$  to raise aggregate consumer welfare is that consumers have a long time horizon.
- If  $DP$  causes  $B$  to exit, then it raises prices for  $L$  consumers in all periods except  $t = 2$ . A sufficient condition for  $DP$  to lower aggregate consumer welfare is that consumers have a long time horizon.
- When the market is more competitive under uniform price, consumers gain less or lose more from  $DP$ .
- As in the basic model, in equilibrium firm  $A$  does not engage in below-cost pricing.

#### 4. Consumer Switching Costs

- We extend the basic model to allow consumer switching cost, by assuming that a consumer incurs a switching cost  $\sigma$  when it changes supplier, and that a modified version of (C1) holds, so that under uniform price  $A$  and  $B$  will strategically avoid head-to-head competition.
- With switching cost, consumers' preferences for different firms' products are affected by their past purchases, which provides a separate incentive for dynamic price discrimination by competing firms.
- Under  $UP$ , the equilibrium outcome is the same as in the basic model, with

$$\{p_{tA}^{u*}, p_{tB}^{u*}\} = \{V_H, p_B^m\} \text{ for } t = 1, 2, \dots, T,$$

all  $H$  consumers purchase from  $A$  and all  $L$  consumers purchase from  $B$  in all periods.

- Under *DP*, there are three possible cases for which the equilibrium analysis differs.

- (i) If  $k \leq (1 - \alpha) \pi_B (c_A - \sigma)$ , there is a unique PBE, where

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{tA}^{a*}, p_{tA}^{b*}), (p_{tB}^{b*}, )\} &= \{(V_H, c_A), c_A + \sigma\} \end{aligned}$$

for  $t \geq 2$ ; *H* and *L* consumers purchase from *A* and *B* respectively.

- This is the case where *B* does not exit, and the result is similar to the basic model, except  $c_A + \sigma$  instead of  $c_A$ .

- (ii) If  $k > (1 - \alpha) \pi_B (c_A + \sigma)$ , there is a unique PBE, where

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{2A}^{a*}, p_{2A}^{b*}), p_{2B}^{b*}\} &= \{(V_H, c_A), c_A + \sigma(1 - \delta)\}, \\ (p_{tA}^{a*}, p_{tA}^{b*}) &= \{(V_H, p_A^m)\} \text{ for } t = 3, \dots, T; \end{aligned}$$

*B* exits and only *A* remains for  $t \geq 3$ .

- This is the case where *B* will exit at the end of  $t = 2$  regardless of its market share; so *A* has no incentive to price below cost at  $t = 2$ .

- We next turn to case (iii),  $(1 - \alpha) \pi_B (c_A - \sigma) < k \leq (1 - \alpha) \pi_B (c_A + \sigma)$ .

- There is a PBE at which firm  $B$  exits at the end of  $t = 2$ ,

$$\begin{aligned} \{p_{1A}^*, p_{1B}^*\} &= \{V_H, p_B^m\}, \\ \{(p_{2A}^{a*}, p_{2A}^{b*}), p_{2B}^{b*}\} &= \begin{cases} \{(V_H, p_b - (1 - \delta) \sigma), p_b\} & \text{if } T = 2n - 1 \\ \{(V_H, c_A + \sigma), c_A\} & \text{if } T = 2n \end{cases} \\ (p_{tA}^{a*}, p_{tA}^{b*}) &= (V_H, p_A^m) \text{ for } t = 3, \dots, T. \end{aligned}$$

where  $n = 2, 3, \dots < \infty$ , and  $p_b - (1 - \delta) \sigma < c_A$ .

- Furthermore, at any possible PBE,  $B$  exits at the end of  $t = 2$ , and  $(p_{tA}^{a*}, p_{tA}^{b*}) = \{(V_H, p_A^m)\}$  for  $t = 3, \dots, T$ .
- In contrast to the situations where  $DP$  arises purely due to consumers' differences in brand preferences, with consumer switching cost the dominant firm may price below cost under  $DP$ , and such below-cost pricing clearly has the purpose and effect of eliminating competition.

## 5. Conclusion

- The effects of dynamic price discrimination on competition and consumer welfare change dramatically from symmetric to asymmetric firms.
- The intensified competition under price discrimination, which tends to benefit consumers in markets with symmetric firms, can cause the exit of a weaker firm and harm consumers in markets with asymmetric firms.
- A sufficient condition for dynamic price discrimination to benefit consumers is that it does not result in firm exit and that consumers have a long time horizon. When the market is more competitive under uniform price, consumers gain less (or lose more) from price discrimination.
- Dynamic price discrimination may or may not appear as predatory in the usual sense, depending on whether there is consumer switching cost.
  - Without switching cost, there will be no below-cost pricing, even if price discrimination causes exit and harms consumers.
  - With switching cost, a dominant firm may price below cost in selling to its rival's customers, with the purpose/effect of eliminating competition.