

# Advertising and prices as signals of quality in a regime of price rivalry

Fluet and Garella (2002)

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# 1 Introduction

- Controversy to whether firms use price or advertising as signals of quality whether advertising has pro- or anti-competitive effects
- Nelson's (1974) - producers signal their products' quality to imperfectly informed consumers. There is a *positive correlation between quality and advertising expenditures* (repeated purchase)
- The theory is supported by Nichols (1998)
- Some literatures against the Nelson's theory:
  - *Advertising is not necessary to signal quality* nor cheaper than alternative signals such as a high price, unless repeat purchase is assumed (Milgrom and Roberts, 1986).
  - Caves and Greene (1996) analyze different correlations between quality and advertising for different groups of products, ranging from negative to positive. *Advertising is generally not used as a signal of quality.*
  - Also, some well known earlier studies provide empirical support against the idea that advertising is used to increase power over price (Brozen, 1974; Benham, 1972).

# Motivation of the paper

- Starting with Nelson's (1974) pioneering theory (repeated purchase)
- Following Nelson, many literatures formed models with and without repeat purchase (Milgrom and Roberts, 1986; Schmalensee, 1978; Horstmann and MacDonald, 1995; Tirole, 1989)
- Linnemer (1998) analyzes the question of entry, Bagwell and Riordan (1991) the role of high introductory prices → Limitation: only considers the interaction between one firm and consumers
- Kihlstrom and Riordan (1984) consider a perfectly competitive industry with free entry, where firms are price-takers. Results → Advertising equilibria can also arise when the interaction among firms and consumers is not repeated, but only if variable unit costs decrease with quality.
- Yang (1994) treats a duopoly with Cournot competition and therefore does not consider price signals
- Motivation of the paper:
  1. Empirical tests have not been able to provide definite support for the relationship between advertising and prices, and quality.
  2. The paper address the issue of whether firms use price or advertising as signals of quality whether advertising has pro- or anti-competitive effects

# The model

- Consider price rivalry
- Two firms compete on the same market
- These two firms do not have established reputation
- Focus on finding separating equilibria and only characterize the signaling mix
- Two firms sending the same high-quality signal need not be believed to be selling high quality

# 2.1 Quality in Monopoly

- Analyze the relationship between signaling strategies and market structure
- A monopolist selling a good that can be of quality  $H$  ( $c > 0$ ) or  $L$  ( $c = 0$ )
- Each consumer buys at most one unit. Utility is zero when not purchasing
- Population of consumers being normalized to unity
- All consumers have the same reservation price for the low quality, but differ in their willingness to pay for H
- A consumer's utility:

$$u_L = 1 - p,$$

$$u_H = 1 + \delta m - p,$$

Where:

$m$  = taste parameter uniformly distributed in  $[0, 1]$

$\delta > 0$  is quality differential between H and L

## a. Complete Information

1) Low Firm ( $D_L = 1$  if  $p \leq 1$  and  $D_L = 0$  if otherwise)

2) High Firm

Consumers buy H if their taste parameter satisfies  $m \geq (p - 1)/\delta$

$D_H = \min [1 - (p - 1)/\delta, 1]$  if  $p \leq 1 + \delta$  and zero otherwise

$$p_L^M = 1 \text{ and } p_H^M = \max [(1 + \delta + c)/2, 1]$$

# 2.1 Quality in Monopoly

## b. Imperfect Information

- Assume  $P_H^M > 1$ ,
- $\sigma = (p, a)$  denotes the strategy
- $b(\sigma)$  is the belief of consumers over firm's strategy
- A separating equilibria entails strategies:

$\sigma_H \neq \sigma_L$ , with the property that  $\sigma_H$  is played if the firm is  $H$  and  $\sigma_L$  is played if it is  $L$ , together with beliefs satisfying  $b(\sigma_H) = 1$  and  $b(\sigma_L) = 0$ .

- $\sigma_L = (p_L^M, 0)$  and  $\sigma_H = (p, 0)$  must satisfy:

$$p_L^M D_L(p_L^M) \geq p D_H(p) - a, \quad (3)$$

$$(p - c) D_H(p) - a \geq \max[0, (p_L^M - c) D_L(p_L^M)]. \quad (4)$$

**Proposition 1.** Under monopoly, if there exists a strategy  $\sigma_H = (p, a)$  with  $a > 0$  satisfying the conditions (3) and (4), then there exists a strategy  $\sigma'_H = (p', 0)$  with  $p' \neq p_L^M$  that also satisfies the same conditions.

Notes: Advertising is not essential for separation. It adds the same cost on FH or FL. It is easier to set  $p' > p_L^M = 1$

## 2.2 Quality in Duopoly (Perfect Info)

- Suppose  $F_L$  and  $F_H$  are simultaneously present in the market and sell at prices  $p_L$  and  $p_H$  respectively
- A consumer is indifferent between the two qualities if  $u_L = u_H$ . Indifference implies  $m = (p_H - p_L) / \delta$

$$d_L(p_H, p_L) = \min [(p_H - p_L) / \delta, 1] \text{ if } p_L < p_H \text{ and zero otherwise.}$$

$$d_H(p_H, p_L) = \min [1 - (p_H - p_L) / \delta, 1] \text{ if } p_H < \delta + p_L \text{ and zero otherwise.}$$

- The BRFs of  $F_L$  and  $F_H$  are:  $p_L = \min [p_H / 2, 1]$  and  $p_H = \max [(\delta + p_L + c) / 2, c]$ . (5)

- The equilibrium prices are:  $p_H^* = (2/3)(\delta + c)$  and  $p_L^* = (1/3)(\delta + c)$ , (6)

- *Necessary and sufficient conditions* for the to have a positive market share in equilibrium:

$$\delta \leq 1 \text{ and } c < 2\delta. \quad (7)$$

- To see this, observe that, when firm  $L$  plays its best reply, the demand to firm  $H$  expressed in terms of its own price is given by:

$$d_H(p_H, p_H/2) = \max [1 - p_H / (2\delta), 0]. \quad (8)$$

$$\text{Set } p_H < 2\delta, c < 2\delta$$

## 2.3 Quality in Duopoly (Imperfect Info)

- Under asymmetric information consumers do not know the quality of either firm.
- Two firms,  $i = 1, 2$ . The possible states:  $(H, H)$ ,  $(L, L)$ ,  $(H, L)$  and  $(L, H)$
- Game stages:
  1. Nature chooses a state of the world and firms observe Nature's choice while consumers do not
  2. First stage - Firms simultaneously choose their strategies  $\sigma_i = (p_i, a_i)$ , for  $i = 1, 2$ .
  3. Second stage - Given the observed strategy profile, consumers revise beliefs and make purchase decisions
- No reputation advantage assumption. Posteriors only depend on the strategies played, irrespective of firms' labels.
- Let  $\alpha_{LL}$  represent the prior probability that the state is  $(L, L)$
- $b^o$  is the prior probability that any given firm is selling high quality:
$$\alpha_{LH} + \alpha_{HH} = \alpha_{HL} + \alpha_{HH} \equiv b^o, \quad (9)$$
- Let  $b_i = (b_1, b_2)$  probability that firm  $i$  is of high quality given the observation of the strategy pair  $(\sigma_1, \sigma_2)$ 
$$b_1(\sigma, \sigma') = b_2(\sigma', \sigma), \quad \text{for all } \sigma, \sigma'. \quad (10)$$
- We use the notation  $\beta(\sigma | \sigma')$  as the probability that a firm playing  $\sigma$  is  $H$  when its rival is playing  $\sigma'$
- Simplified case where the prior probability of state  $(H, H)$  is zero, that is  $\alpha_{HH} = 0$

# 3.1 Necessary conditions for separation

- A separating equilibrium is one where:
  - (i) firms play pure strategies;
  - (ii) to each state of Nature corresponds a different equilibrium strategy profile, denoted as  $(\sigma_0, \sigma_0)$  for state  $(L, L)$ ,  $(\sigma_H, \sigma_L)$  for  $(H, L)$  and  $(\sigma_L, \sigma_H)$  for  $(L, H)$ , with  $\sigma_H \neq \sigma_L$ ;
  - (iii) posterior beliefs about the quality of each firm are either 0 or 1;
  - (iv) beliefs are confirmed at equilibrium.

- A separating equilibrium must satisfy (make no claim on sufficiency):

$$\pi_L(\sigma_L, \sigma_H) \geq \pi_L(\sigma_H, \sigma_H), \quad (\text{A})$$

$$\pi_H(\sigma_H, \sigma_L) \geq \max[0, \pi_H(\sigma_L, \sigma_L)]. \quad (\text{B})$$

- A deviation by firm  $L$  to the action  $\sigma_H$  modifies the consumers' perception of both firms' types; that is, two firms playing  $\sigma_H$  are not perceived as two high-quality firms

**Lemma 1.** *At any separating equilibrium, firm  $L$  does not advertise in an asymmetric state and it plays  $\sigma_L = (p_L, 0)$ , where  $p_L = \min[(p/2), 1]$  is its full information best reply price against  $\sigma_H = (p, a)$ .*

# 3.1 Necessary conditions for separation

- If firm  $L$  mimics the price and advertising of firm  $H$ , consumers assign to each firm the same probability  $\beta$  ( $\sigma_H | \sigma_H$ )
- For a consumer with taste parameter  $m$  and letting  $\beta$  ( $\sigma_H | \sigma_H$ ) =  $b$ , this expected utility is equal to

$$bu_H + (1 - b)u_L = 1 + b\delta m - p. \quad (11)$$

- A consumer with taste parameter  $m = (p-1)/(\delta b)$  is therefore indifferent between purchasing and not purchasing
- Following the observation of ( $\sigma_H | \sigma_H$ ), the total market demand for the undifferentiated product is:

$$D_b(p) = \begin{cases} \max[0, (1 - (p - 1)/(b\delta))] & \text{if } p > 1 \\ 1 & \text{if } p \leq 1 \end{cases} \quad (12)$$

- Since prices are the same at both firms, the demand is shared equally between the two firms, condition A becomes:

$$\pi_L(\sigma_H, \sigma_H) = (1/2)pD_b(p) - a \quad (13) \quad \text{If L mimics}$$

$$p^2/(4\delta) \geq (1/2)pD_b(p) - a \quad (A)$$

- Condition B, if the H sticks to the equilibrium strategy, becomes:

$$(p - c)d_H(p, p_L) - a = (p - c)\max[1 - p/(2\delta), 0] - a \quad (14)$$

$$(p - c)\max[1 - p/(2\delta), 0] - a \geq \frac{1}{2} \max\left[\frac{p}{2} - c, 0\right] \quad (B)$$

# 3.1 Necessary conditions for separation

**Lemma 2.** *If  $\delta \leq 1/2$  and  $c \geq \delta$ , there exists no separating equilibrium with positive market share for  $H$  in an asymmetric state.*

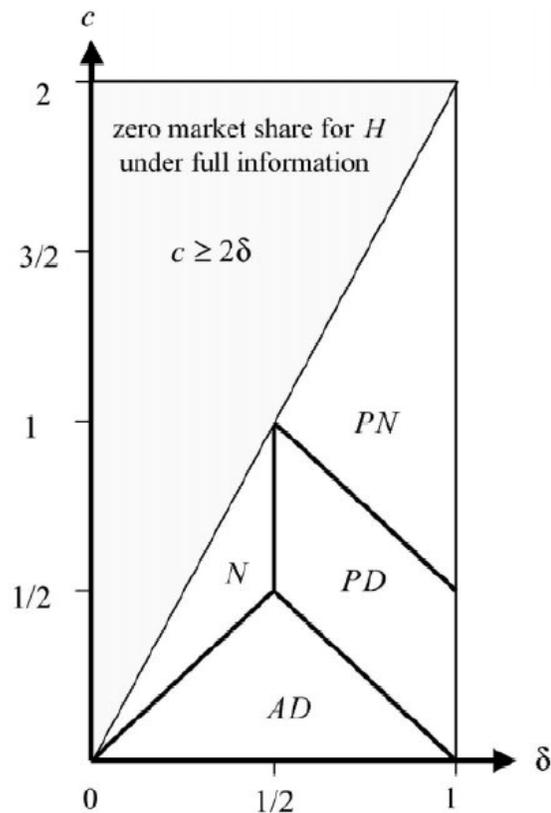
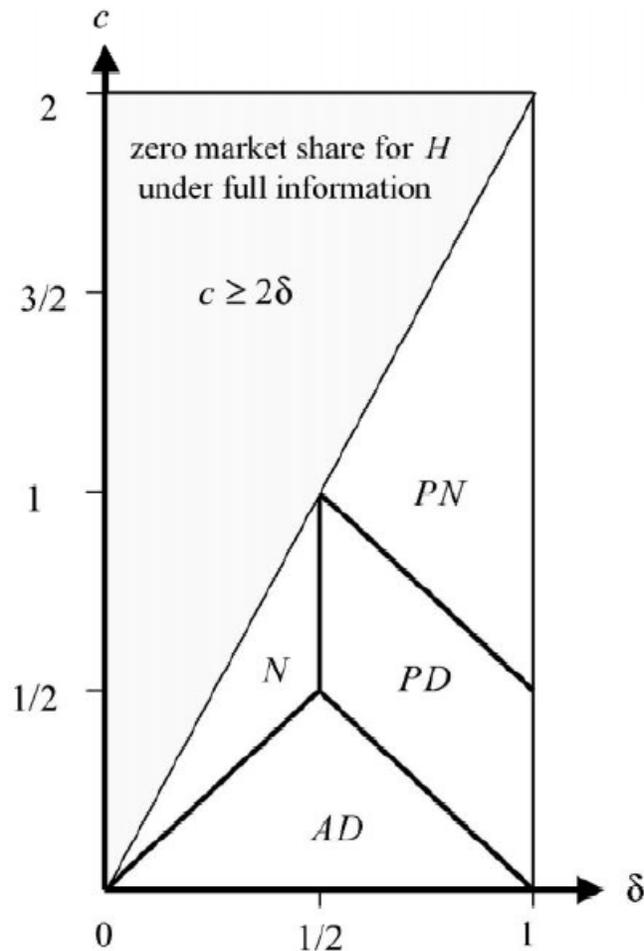


Fig. 1. Regions for the existence of separating equilibria.

- There exists no separating equilibrium with positive market share for  $F_H$  for parameter values in the area denoted  $N$
- Conditions A and B can't hold simultaneously when  $\delta \leq 1/2$  and  $c \geq \delta$
- Intuition of region  $N$ :
  1. When  $\delta$  is small and because of price competition,  $F_H$  must sell at a price below reservation price for  $F_L$  (otherwise  $F_H$  has no market).  $F_L$  has incentive to pool by increasing price  $\rightarrow$  price signaling is not viable
  2. Advertising can prevent mimicking  
Condition B reveals the existence of a separating equilibria with advertising exist. Given  $c \geq \delta$ ,  $\pi_H$  is small.  $F_H$  can't set a high price and can't afford the advertising cost to prevent mimicking

# 3.2 Separating equilibria



Where:

AD = Advertising and Distortion,  $c < 1$  and  $c \leq 1 - \delta$

PD = Price and Distortion,  $\delta > 1/2$  and  $1 - \delta < c \leq (3/2) - \delta$

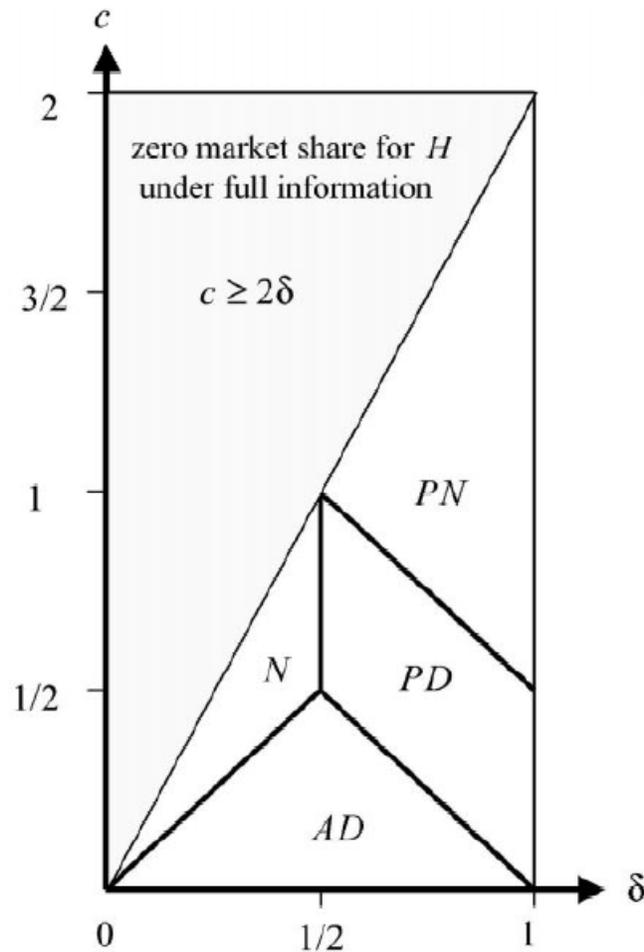
PN = Price and No Distortion ( $\delta > 1/2$  and  $c > (3/2) - \delta$ )

**Lemma 3.** For  $\delta \leq 1/2$ , any separating equilibrium, if it exists, implies strictly positive advertising expenditures by the high quality firm in the states  $(H, L)$  and  $(L, H)$ . Furthermore, any equilibrium with zero advertising, namely  $\sigma_H = (p, 0)$ , implies  $p > 1$ .

- When quality differential,  $\delta$ , is small, advertising ( $a > 0$ ) is necessary to signal quality  $\rightarrow$  **AD** with  $\delta \leq 1/2$
- When quality differential is high ( $\delta > 1/2$ ), a separation without advertising ( $a = 0$ ), requires  $p > p_L = 1$  (setting price above  $p_L$ )

Fig. 1. Regions for the existence of separating equilibria.

# 3.2 Separating equilibria

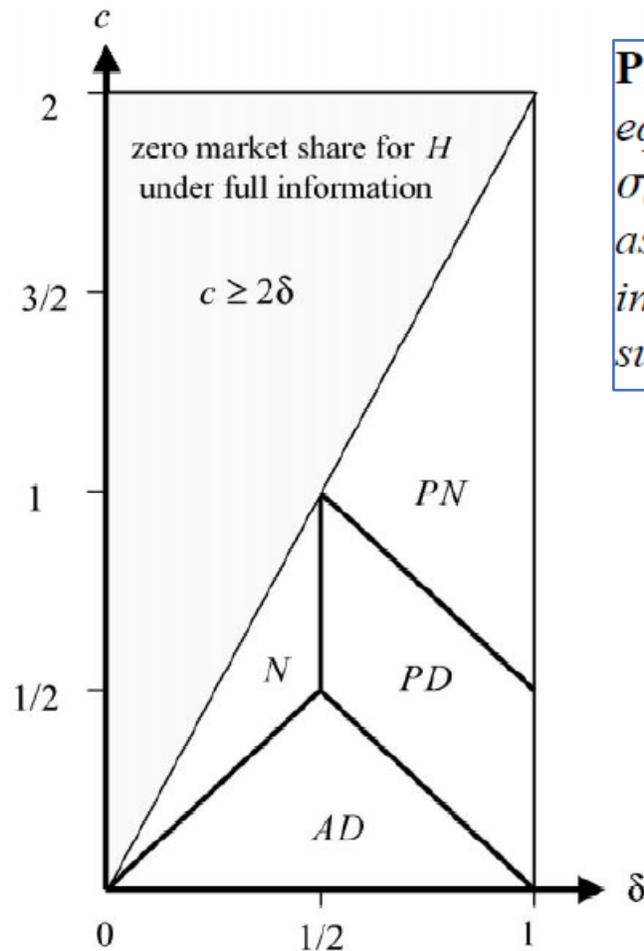


**Proposition 2.** *Except for parameter values in region N, there exists a separating equilibrium such that in state (L, L) both firms play the full information strategy  $\sigma_0 = (0, 0)$ . (i) In region AD, the signaling mix of the high quality firm in an asymmetric state involves  $a > 0$ ; (ii) in region PD, it involves  $p > p_H^*$  or  $a > 0$ ; (iii) in region PN, the full information equilibrium prices without advertising are sufficient for separation.*

- Explanation on a separating equilibrium in the state (L, L), For any  $\sigma \neq \sigma_H, \sigma_0$ :
  1.  $(\sigma_0, \sigma)$  interpreted as (L, L)
  2.  $(\sigma_L, \sigma)$  interpreted as (L, L)
  3.  $\sigma_H$  signals the high quality if and only if played against  $\sigma$

Fig. 1. Regions for the existence of separating equilibria.

# 3.2 Separating equilibria



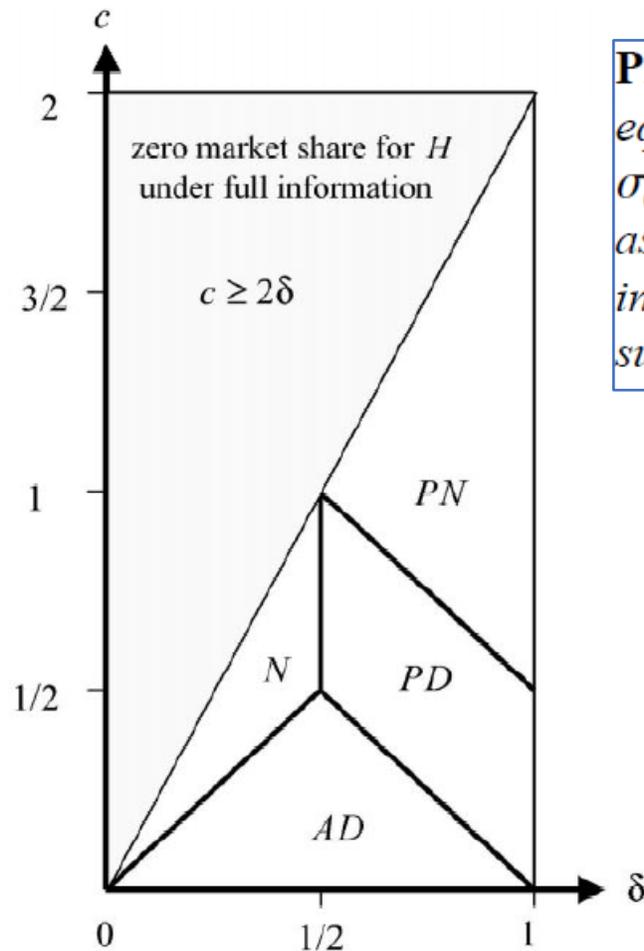
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- Explanation in region PD:

In region *PD*, the full information price for *H* in the asymmetric states is less than unity; this corresponds to a relatively small unit cost and/or quality differential. As a result, separation requires an upward price distortion or positive advertising (or both).

Fig. 1. Regions for the existence of separating equilibria.

# 3.2 Separating equilibria



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- Explanation in region PN:

The region PN instead is defined by the inequality  $p_H^* > 1$ . For appropriate beliefs, firm L will then not mimic the full information price and separation can occur without price distortions and with zero advertising.

Fig. 1. Regions for the existence of separating equilibria.

# 4 Additional pooling equilibria

- Possibility of using frills as well as fixed cost advertising (in addition to price) allows separation in region  $N$
- ‘frills’ refers to the possibility of imbedding advertising expenditures in the product or in the conditions of sale
- Let  $k$  denote the fixed-cost advertising and  $s$  the per-unit expenses on frills
- The advertising policy is the pair  $(k, s)$ .
- The high-quality firm’s equilibrium strategy is now  $\sigma_H(p, k, s)$ .
- In this case, Lemma 1 still holds, so that in  $F_H$  equilibrium, the  $F_L$  plays  $\sigma_L(p_L, 0)$  as its best response
- With the beliefs defined in Section 3, the conditions A and B remain necessary and sufficient for a separating equilibrium  $p < 2c$ , but these conditions now write as:

$$p^2/(4\delta) \geq (1/2)(p - s)D_b(p) - k \quad (A')$$

and

$$(p - c - s)[1 - p/(2\delta)] - k \geq (1/2) \max[(p/2) - c, 0]. \quad (B')$$

# 4 Additional pooling equilibria

- If  $F_L$  mimics, it must sell at price  $p$ , incur the fixed-cost advertising  $k$  and the per-unit expense  $s$ . This leads to the net profit defined on the RHS of the no-deviation condition  $A'$ .
- Similarly, the cost of frills has been taken into account in the left-hand-side of  $B'$ .

Defining  $a = (1/2)sD_b(p) + k$ , and  $\hat{a} = s[1 - p/(2k)] + k$ , the conditions  $A'$  and  $B'$  can be rewritten as

$$p^2/(4\delta) \geq (1/2)pD_b(p) - a \quad (A')$$

$$(p - c)[1 - p/(2\delta)] - \hat{a} \geq (1/2) \max[(p/2) - c, 0]. \quad (B')$$

- The form of advertising is different because when  $F_L$  mimics, its market share is usually different than of  $F_H$  under equilibrium strategies
- We show that, if frills can be used, a separating equilibrium exists over the whole parameter set; that is, whenever the high quality has positive market share under full information.

**Proposition 3.** *If frills are feasible, separating equilibria exist for all  $\delta$  and  $c$  in the parameter space.*

# 5 Pooling equilibria

- Separating equilibria are not the only type of equilibria that exist in the game.
- It is possible to construct belief systems such that no scope for separation is left.
- Let  $\sigma^P$  denote the strategy that both firms play at a pooling equilibrium.
- We illustrate the case where  $\sigma^P = (p, 0)$ , for some  $p$ .
- By definition of a pooling equilibrium, beliefs must satisfy  $\beta(\sigma^P | \sigma^P) = b_0$  where  $b_0$  denotes the prior probability that any given firm produces quality  $H$ .
- One possible set of out-of-equilibrium beliefs is the following: if one firm deviates to any other strategy, it is believed to be  $F_L$ , while the firm sticking to strategy  $\sigma^P$  is perceived as  $F_H$ 
  - if both firms play strategies different from  $\sigma^P$ , both are perceived as  $L \rightarrow$  this specification implies maximum penalty for the deviating firm in the sense that, if  $\sigma^P$  is not supported as an equilibrium with these beliefs, no other specification will.

# 5 Pooling equilibria

**Proposition 4.** *A pooling equilibrium with  $\sigma^P = (p, 0)$  exists if and only if  $c \leq p \leq \max[2\delta, 2(b_0\delta + 1)/(2 + b_0)]$ .*

- A type  $L$  firm, cannot quote a higher price otherwise it loses all customers, but could deviate to a price below  $p$ .
  - Under the proposed belief system, it would in that case be perceived as  $L$  and its rival as  $H$ . The upper bound on  $p$  guarantees that this deviation is not profitable.
- For a type  $H$  firm the reasoning is the same, given that the lower bound on  $p$  guarantees non-negative profits.
- Observe that the condition also implies  $c < 2(b_0\delta + 1)/(2 + b_0)$ .
- This upper bound is a straight line separating the admissible region of the parameter space in two parts. For all priors  $b^0$  in  $(0, 1)$ , this line is above  $c = 1$  and that it therefore lies inside region  $PN$ .
- The set of parameter values for which there is no pooling equilibrium is consequently a proper subset of region  $PN$ .
- This means that, when a pooling equilibrium does not exist, there exists a separating equilibrium with full information prices.

# 6 Conclusions

1. When there is price rivalry, advertising may be necessary to signal quality, in contrast to single-firm models.
2. Signaling through price alone prevails for sufficient inter-brand quality differentials
3. Joint price-advertising signals prevail when the quality differential is small
4. Advertising in the form of variable rather than fixed costs is shown to increase the feasibility of signaling quality