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Information transmission and incentives not to price discriminate*

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Abstract. This paper analyzes how the pricing policy of an incumbent may signal information not only on the demand level but also on the demand composition. A signalling game with two periods and two players (an established firm and a potential entrant) is considered. The potential entrant has incomplete information on market demand. There exist many sequential equilibria in which the uniform price policy acts as an entry deterrence device by hiding actual market profitability. We can interpret the uniform pricing policy as a rejection of the use of superior information on market demand composition in order to reduce the entrant's expected profits.

JEL classification: D43, D82

Key words: Asymmetric information, price discrimination, entry deterrence, uniform pricing

1 Introduction

It is natural to assume that an established firm has more information on market characteristics than a potential entrant. In particular, the incumbent may have some private information concerning the composition of the market demand.[1] If the pre-entry pricing policy is used by a potential entrant to infer the private

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[1] As Bain (1949) says "Industry demands are never certainly known, and they are probably known less fully by potential entrants than by established firms". Roberts (1986), Bagwell and Ramey (1990) and Mailath (1991) also consider incumbent firms with private information on market demand.

information of the incumbent and, thus, to estimate the profitability of entry, the incumbent has an incentive to distort the information transmitted by its pricing rule. We show how an established firm, which is able to price discriminate, may price uniformly in order to hide the profitable segmentability of the market in order to deter entry.

The idea that pre-entry prices offer information on market conditions has been present in theoretical literature since Bain (1949). Milgrom and Roberts (1982) adopt a game theory approach to analyze how prices may signal information about the incumbent's costs.[2] In the separating equilibrium of their model the established firm practices limit pricing, but entry is not deterred because the entrant infers the actual cost of the incumbent. Masson and Shaanan (1982), (1987) find evidence indicating that entry levels react to pre-entry profits and that in the presence of entry threats, the profitability of incumbents is below the short-run maximizing level.

Consider a market where a monopolist is able to distinguish two different groups or segments among its customers on the basis of some exogenous information (i.e, age, location, occupation,..).[3] If submarkets differ in demand elasticity, the segmentation of the market (which requires the prevention of resale or arbitrage between submarkets) benefits the monopolist; it would be able to charge different prices to different purchasers whereas if the market were unified it should fix a single price. A monopolist would always prefer the discrimination regime to the uniform price regime since it could always choose not to discriminate.[4]

However, the above result depends crucially on the non-existence of strategic interaction. For instance, a durable-good monopolist could prefer uniform pricing to price discrimination. In particular, a most-favoured-customer clause (which commits to uniform pricing) can be used by a durable-good monopolist to credibly commit to a permanently high price, thus eliminating the dynamic inconsitency associated with the pricing of a durable good (see, for example, Butz, 1990). In oligopolistic settings, some studies have shown that MFC clauses (that is, commitments not to price discriminate) can facilitate collusion (see, for example, Cooper 1986 and Salop 1986) or may be used to obtain a competitive advantage over rivals (see, Aguirre 1996b). Holmes (1989) studies the multimar-

[2] Recent studies in which the incumbent's pre-entry behaviour gives information on its private information are Matthews and Mirman (1983), Harrington (1986) and Bagwell and Ramey (1988), (1990), von der Fehr (1992) and Aguirre et al. (1998). See Salop (1979) for references on preceding work.

[3] In this paper, the determination of the different groups of consumers is taken as exogenous to the model. Of course, the choice of how to divide the market is a very important consideration for a monopolist. See Varian (1989) for a discussion. There is a vast marketing literature on market segmentation. See Beane and Ennis (1987), for a review of the many ways that markets can be segmented and the tools that are used in segmenting markets (factor analysis, cluster analysis, discriminant analysis and so on).

[4] Third-degree price discrimination can occur, for example, when the seller can isolate customers either geografically (the home and the export markets) or by age (Senior Citizen's discounts) or by occupation (student discounts) or in time (initial equipment and replacement purchases) or by end use (milk for liquid consumption or for further processing).

ket competition between firms in a product differentiation setting and analyzes the effect of third-degree price discrimination on duopoly profits. He shows that the direction of the effect on total profit is in general ambiguous. Firms in an oligopoly may be worse off with a larger choice set; that is, a duopoly may obtain greater profits under uniform pricing than under price discrimination.

In this paper, we provide an explanation for not price discriminating (when possible) based on information transmission. Let us assume that there is a potential entrant considering whether to enter the market and that the information it has on market demand composition is incomplete; in particular, it does not know whether submarkets are separated or not.[5] This information is crucial for its entry decision since post-entry competition in a segmentable market is different from that in an integrated market. When submarkets are separated we can consider competition between firms as a multimarket competition: each firm independently chooses its strategic variable (price or quantity) in each submarket. Note that in this case price discrimination across submarkets is possible. In a unified market, the single price constraint reduces the strategic choice set of each firm. We assume, throughout the paper, that duopoly profits are higher in a segmentable market, that is, a discriminating duopoly obtains more profits that a nondiscriminating one.[6] In this setting, the entrant has incentives to control the pre-entry pricing behaviour of the incumbent and, with this information, update its beliefs concerning market demand and, thus, also concerning its post-entry profitability. Note that selling at different prices reveals information on the existence of customer groups that differ in demand elasticities and that can be profitability separated. Thus, the incumbent has an incentive not to use its private information and to price uniformly. We can interpret the uniform pricing policy as a rejection of the use of superior information on market demand composition in order to reduce the profits expected by the entrant.[7]

We consider a signalling game with two periods and two players: an incumbent and a potential entrant. The latter has incomplete information about market demand composition. We consider two types of market structure, s and ns. Demand type s is such that it is possible to price discriminate because there are two perfectly separated submarkets that differ in demand elasticity. From now

[5] Equivalently, this uncertainty about the possibility of arbitrage can be seen as uncertainty about consumers' transport costs or consumers' value of time or taxes. In other terms, given that the separability of the market is related to the capability to price discriminate, the uncertainty may refer to the degree of hostility of Antitrust Authority towards price discrimination. It is natural to assume that an established firm has more information on the above market characteristics than a potential entrant.

[6] As Holmes (1989) states, this ranking of duopoly profits is not general. However, as he shows, profits increase with price discrimination if the total output of each firm does not decrease. The effect of discrimination on output depends on the relative curvature of demand in the two submarkets and on the elasticity-ratio condition. In Sect. 2, we consider linear demands and two kinds of post-entry competition: Cournot competition with homogeneous product and Bertrand competition under product differentiation. In the first case price discrimination is profit improving, and in the second case, we state a condition similar to that of Holmes, for price discrimination increases profits.

[7] Smiley (1988), in a study based on questionnaires from nearly 300 firms, suggests that masking data on profitability is the most commonly chosen entry-deterring strategy. Notice that if an incumbent is able to price discriminate prices uniformly then it is hiding the actual market profitability.

on we shall refer to this as a segmented market. When the demand is type *ns*, it is not possible to price discriminate because there is perfect arbitrage (that is, it is impossible to prevent resale). We refer to this as a non-segmented or unified market. Thus, the entrant lacks complete information on whether it is possible or not to price discriminate in the market. In the first period, the existing firm chooses prices under one of two alternative policies: uniform price or price discrimination. The established firm is a monopolist at this stage. The potential entrant observes the pricing policy charged by the incumbent and updates its beliefs concerning market demand. On the basis of this information, the entrant decides whether to enter or to stay out. In the second period, the incumbent's type is made common knowledge; if there is entry, both firms choose production (or price) levels simultaneously and independently; otherwise, the incumbent behaves as a monopolist.

As is usual in signalling games, we find a multiplicity of separating and pooling sequential equilibria. In the separating equilibria, the non-segmented market firm reduces (or increases) its price (compared with the case of complete information) and the segmented market firm price discriminates. Entry occurs exactly when it would have occurred under symmetric information. In the pooling equilibria, incumbent type *s* uses the uniform pricing policy and chooses the same price as type *ns* in order not to reveal its private information to the entrant. These equilibria share the feature that uniform pricing policy would act as an entry deterrence device by hiding crucial information on market demand. We refine the set of equilibria by restricting posterior beliefs. In addition to the elimination of weakly dominated strategies we consider the intuitive criterion (Cho and Kreps 1987) and divinity (Banks and Sobel 1987; D1 in Cho and Kreps 1987). The weak dominance and the intuitive criterion select the ”least cost” separating equilibria; but there is a continuum of pooling equilibria satisfying these criteria. However, we show that there is only one pooling equilibrium which satisfies criterion D1. In this equilibrium the incumbent in possesion of more attractive information discourages entry by charging a uniform price.[8]

This paper is organized as follows. Section 2 gives a description of the model. Section 3 characterizes separating and pooling equilibria and Sect. 4 studies refinements. Finally, Sect. 5 offers concluding comments.

2 The model

Consider a market in which an incumbent, firm I, and a potential entrant, firm E, interact for two periods. In the first period the established firm monopolizes the market. At the end of the period, the entrant firm decides whether to enter or not

[8] Another study where the most sensible outcome conveys pooling equilibria is that of von der Fehr (1992). He shows that if pre-entry profits are used by potential entrants to estimate the profitability of entry, it may be in the interest of incumbent firms to reduce apparent profits in order to deter entry. The incumbent has an incentive to strategically manipulate profit reports and the owners of firms will accept below maximum profit performance (that is, they will tolerate slack) in order to deter entry.

in the following period. In the second period, if there is entry the firms obtain duopoly profits, whereas if entry does not occur, the incumbent remains as a monopolist. The main feature of the market is that the entrant firm makes its entry choice without having complete information on the market demand composition, and therefore, on the degree of rivalry it will face once having entered. However, it may try to infer some information by observing the incumbent's first period pricing policy.

The entrant has incomplete information about the market demand. It is aware of the demand of each submarket but it does not know whether the two segments can be effectively separated. There are two possible market demand configurations: X^s and X^{ns}, where $X^s \equiv \{D_i^s(p_i, p_j) = \frac{\alpha_i}{\beta_i} - \frac{1}{\beta_i}p_i;\ \mathrm{i, j} = 1, 2, \mathrm{i} \neq \mathrm{j}\}$ and $X^{ns} \equiv \{D_i^{ns}(p_i, p_j) = \frac{\alpha_i}{\beta_i} - \frac{1}{\beta_i}\min\{p_i, p_j\};\ \mathrm{i, j} = 1, 2, \mathrm{i} \neq \mathrm{j}\}$. A market demand configuration specifies the demand of each submarket and the resale (arbitrage) possibilities. When the demand configuration is X^s there are two separated submarkets that differ in demand elasticity. From now on, we shall refer to this as a segmented market and to the established firm as the incumbent type s. When the demand configuration is X^{ns} submarkets are not separated (there is perfect arbitrage).[9] From now on, we shall refer to this as a nonsegmented or unified market and to the established firm as type ns. Note that both types of incumbents have the same submarket demands and that the only difference between them is whether there is arbitrage or not. Let $\mu^o \in (0, 1)$ be the entrant's prior probability assessment of the event that the demand configuration is X^s. Marginal production costs are constant and identical for both firms; for the sake of notational simplicity prices are expressed net of marginal cost. The entrant firm has to incur a fixed cost f_E if it enters.

Denote as $P \equiv (p_1, p_2)$ the first period pricing policy of the incumbent. First period profits are: $\Pi_t(P) = \Pi_t(p_1, p_2) = p_1 D_1^t(p_1, p_2) + p_2 D_2^t(p_1, p_2) \quad t = s, ns$.

Let $P_s^m \equiv (p_1^m, p_2^m)$ be the monopoly pricing policy when the incumbent is type s. The incumbent type s sells the same commodity in two separated submarkets with different demand elasticity. Thus it engages in price discrimination by charging the higher price in the less price sensitive market. Without loss of generality we assume that $\alpha_1 > \alpha_2$ and as $p_i^m = \frac{\alpha_i}{2}$, $i = 1, 2$, then $p_1^m > p_2^m$. The monopoly profit of type s is $\Pi_s^m = \Pi_s(P_s^m) = \frac{1}{\beta_1}(p_1^m)^2 + \frac{1}{\beta_2}(p_2^m)^2$.

Denote as $P_{ns}^m \equiv (p_{ns}^m, p_{ns}^m)$ the monopoly pricing policy of type ns. As its submarkets are not separated this type of incumbent charges a single price, $p_{ns}^m = \frac{\alpha_1\beta_2 + \alpha_2\beta_1}{2(\beta_1 + \beta_2)}$. The monopoly profit of the non-segmented market incumbent, type ns, is $\Pi_{ns}^m = \Pi_{ns}(P_{ns}^m) = \frac{(\beta_2 + \beta_1)}{\beta_1\beta_2}(p_{ns}^m)^2$. We assume that $\frac{\alpha_2}{\alpha_1 - \alpha_2} > \frac{\alpha_1/\beta_1}{\alpha_1/\beta_1 + \alpha_2/\beta_2}$ and, therefore, that $\Pi_{ns}^m > \Pi_{ns}(P_1^m)$, where $P_1^m \equiv (p_1^m, p_1^m)$. This condition guarantees that both submarkets are served under uniform pricing. Note that if type s had to charge a uniform price (for instance, because price discrimination is banned) it would price at $p_s^u = p_{ns}^m$; hence, $p_1^m > p_{ns}^m > p_2^m$. As a consequence $\Pi_s^m > \Pi_{ns}^m$,

[9] A similar setting would be to consider a case in which the potential entrant has incomplete information about consumers' transportation cost, t, between submarkets, where $t \in \{t_{ns}, t_s\}$ with $t_{ns} = 0$ and t_s is high enough to discourage resale.

the monopolist is better off under price discrimination, because in the worst of cases it can always charge the same price in each submarket.

We shall now consider competition in the second period. There are two cases: (i) no entry, and therefore each type of incumbent behaves as a monopolist; (ii) entry, and both the incumbent and entrant firms choose their strategic variables simultaneously and independently. We allow two kinds of post-entry competition: Cournot competition with homogeneous product, and Bertrand competition with product differentiation. In any case post-entry competition and entry profitability depend on the type of incumbent.

When the demand structure is type s, submarkets are completely separated. We may consider the post-entry competition as a multimarket oligopoly: each firm produces two independent commodities and, therefore, independently chooses the strategic variable of each submarket.[10] Firstly we consider Cournot competition. Denote by x_i^I and x_i^E the equilibrium output levels of firm I and E in submarket i, $i = 1, 2$. It is easy to check that $x_i^I = x_i^E = \frac{\alpha_i}{3\beta_i}$, and that the Cournot price in submarket i is $p_i^C = \frac{\alpha_i}{3}$, $i = 1, 2$. Denote by Π_s^I and Π_s^E the equilibrium profits of the incumbent and the entrant, respectively. Given the equilibrium pricing policy, $P_s^C \equiv (p_1^C, p_2^C)$, we can express the equilibrium profits as: $\Pi_s^I = \frac{1}{\beta_1}(p_1^C)^2 + \frac{1}{\beta_2}(p_2^C)^2$ and $\Pi_s^E = \frac{1}{\beta_1}(p_1^C)^2 + \frac{1}{\beta_2}(p_2^C)^2 - f_E$.

So as to be able to analyze Bertrand competition with differentiated products, we need to specify the demand for the product variety of firm F, $F = I, E$, in each submarket. Consider the following system of direct demands: $D_i^F(p_i^F, p_i^G) = a_i - b_i p_i^F + c_i p_i^G$, $F, G = I, E, F \neq G$, $i = 1, 2$, where p_i^F is the price of F in market i.[11] We assume that $b_i > c_i > 0$, $i = 1, 2$. The equilibrium price levels are: $p_i^B = p_i^I = p_i^E = \frac{a_i}{2b_i - c_i}$ and the equilibrium profits: $\Pi_s^I = b_1(p_1^B)^2 + b_2(p_2^B)^2$ and $\Pi_s^E = b_1(p_1^B)^2 + b_2(p_2^B)^2 - f_E$.

When the demand structure is type ns, submarkets are not separated. Therefore, we may consider it as a unified market. Under Cournot competition, the outcome is the same when firms engage in output competition in each submarket with a single price constraint as when each firm decides the total output considering the aggregate inverse demand. The equilibrium (total) output levels are: $x^I = x^E = \frac{\alpha_1\beta_2 + \alpha_2\beta_1}{3\beta_1\beta_2}$ and the Cournot price $p^C = \frac{\alpha_1\beta_2 + \alpha_2\beta_1}{3(\beta_1 + \beta_2)}$.

Given the equilibrium pricing policy, $P_{ns}^C \equiv (p^C, p^C)$, we can express the equilibrium profits as: $\Pi_{ns}^I = \frac{(\beta_1 + \beta_2)}{\beta_1\beta_2}(p^C)^2$ and $\Pi_{ns}^E = \frac{(\beta_1 + \beta_2)}{\beta_1\beta_2}(p^C)^2 - f_E$.

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[10] As the market is segmented, it is natural to assume that firms consider the output (or price) levels of each submarket as independent strategic variables. Neven and Phlips (1985), and Holmes (1989), for example, also consider this assumption in a similar price discrimination context. In the literature of spatial price discrimination (a case of third-degree price discrimination), it is assumed that firms compete at each market location separately. See, for example, in the case of Cournot competition, Hobbs (1986), Hamilton et al. (1989) and Anderson and Neven (1991), and in the case of Bertrand competition, Lederer and Hurter (1986), Thisse and Vives (1988) and Aguirre et al. (1998). See Krugman (1989) for similar assumptions in international trade settings.

[11] We consider that the utility function (separable and linear in the *numeraire* good) of a representative consumer in market i, $i = 1, 2$, is $U_i(x_i^I, x_i^E) + y_i = \alpha_i(x_i^I + x_i^E) - \frac{1}{2}[\beta_i(x_i^I)^2 + 2\gamma_i x_i^I x_i^E + \beta_i(x_i^E)^2] + y_i$. Letting $a_i = \frac{\alpha_i}{\beta_i + \gamma_i}$, $b_i = \frac{\beta_i}{\beta_i^2 - \gamma_i^2}$ and $c_i = \frac{\gamma_i}{\beta_i^2 - \gamma_i^2}$, the maximization of the representative consumers in markets 1 and 2 yields the demand system.

Under Bertrand competition each firm chooses a single price given there is perfect arbitrage and thus it is not possible to price discriminate between markets. Equilibrium prices are: $p^B = p^I = p^E = \frac{a_1+a_2}{2(b_1+b_2)-(c_1+c_2)}$ and equilibrium profits are: $\Pi^I_{ns} = (b_1+b_2)(p^B)^2$ and $\Pi^E_{ns} = (b_1+b_2)(p^B)^2 - f_E$.

We make the following assumptions:

(A1) $\Pi^F_s > \Pi^F_{ns}$, $F = I, E$.
(A2) $\Pi^E_s > 0 > \Pi^E_{ns}$
(A3) $\mu^o \Pi^E_s + (1-\mu^o)\Pi^E_{ns} \leq 0$

Assumption (A1) implies that a duopolistic firm obtains more profits under price discrimination (segmentation) than under uniform pricing (nonsegmentation). A sufficient condition for price discrimination to increase duopolistic profits is that output should not decrease. It is easy to check that under Cournot competition with homogeneous product, the total output of each firm is the same under both regimes; therefore, price discrimination increases profits. Under Bertrand competition suppose that $p^B_1 > p^B_2$ (the elasticity in absolute value of the residual demand of firm F is lower in market 1), then output and profits increase with price discrimination if $\frac{b_2}{c_2} > \frac{b_1}{c_1}$. Assumption (A2) says that the entry cost f_E is such that, under symmetric information, firm E would enter if and only if the market demand were type s. (A3) implies that, with the prior information, the expected profits of the entrant are nonpositive. Finally, we assume that the discount factor is $\delta \in [0,1]$.

The timing of the game is as follows:

Period 1. The incumbent, firm I, chooses a pricing policy, $P \equiv (p_1, p_2)$ and sells in both submarkets as a monopolist.[12] At the end of the period the entrant, firm E, observes the pricing rule and price levels. Then, the entrant decides whether to enter or not in the following period. If it enters, it incurs an entry cost, f_E.

Period 2. The incumbent's type is made common knowledge and if there is entry both firms choose prices (quantities) simultaneously and independently; otherwise, the incumbent behaves as a monopolist.

The incumbent type s can choose any pricing policy $P \equiv (p_1, p_2)$ with $p_1, p_2 \in \mathbb{R}_+$. For the incumbent type ns a pricing policy $P \equiv (p_1, p_2)$ with $p_1 \neq p_2$, is equivalent to a pricing policy $P' \equiv (p_2, p_2)$ if $p_2 = \min\{p_1, p_2\}$, because there is perfect arbitrage. We assume that the entrant observes a price if and only if demand at that price is positive.[13] Hence the incumbent type ns can choose any pricing policy $P \equiv (p, p)$ with $p \in \mathbb{R}_+$.

[12] Equivalently, the incumbent chooses quantities in the first period but only prices are observed.

[13] If we allow that prices can be observed whether or not they trigger some positive demand, then the higher price of the incumbent type ns would not be a costly signal. The nonsegmented demand incumbent could directly reveal its type to the entrant without costs: for instance, with the pricing policy ($p_1 = \infty$, $p_2 = p^m_{ns}$) the incumbent type ns would obtain monopoly profits, inform the entrant about its type and deter entry. However, we think that it is more natural to assume that the entrant only observes the effective price ($p = \min\{p_1, p_2\}$) in the market and, therefore, we shall ignore the above possibility.

The strategy of the incumbent is $(P_t)_{t=s,ns}$ and let the strategy of the entrant be denoted by $e(P) \in \{0,1\}$ where $e = 1$ means entry. Denote by $\mu(P) \in [0,1]$ the posterior belief of the entrant that the type of the incumbent is s when it observes P. The collection $\{(P_t)_{t=s,ns},\ e(P), \mu(P)\}$ forms a sequential equilibrium if the following conditions are satisfied:

a) The strategy of each type of the incumbent firm is sequentially rational. For $t = s, ns$,

$$P_t \in \underset{\{P\}}{\operatorname{argmax}}\{\Pi_t(P) + e(P)\Pi_t^I + [1 - e(P)]\Pi_t^m\}$$

b) The entrant reacts optimally to the pricing policy of the incumbent given its posterior beliefs. For any P, $e(P) = 1$ if and only if $\mu(P)\Pi_s^E + [1-\mu(P)]\Pi_{ns}^E > 0$.

c) The system of the posterior beliefs of the entrant is Bayes-consistent. If $P_s \neq P_{ns}$ then $\mu(P_s) = 1$ and $\mu(P_{ns}) = 0$. If $P_s = P_{ns}$ then $\mu(P_s) = \mu^o$. If $P \neq P_s, P_{ns}$ then the consistency requirement does not constrain beliefs and any $\mu(P) \in [0,1]$ is consistent. That is, if P is not part of the optimal strategy of the incumbent for any particular type, observing P is a zero-probability event and Bayes' rule does not pin down posterior beliefs. Any posterior beliefs $\mu(P) \in [0,1]$ are then admissible.

In the next section, we shall characterize the sequential equilibria. As is usual in signalling games there is a multiplicity of equilibria. In Sect. 4 we use some refinement criteria in order to select among equilibria.

3 Sequential equilibria

We consider two kinds of potential equilibrium: separating and pooling.[14]

3.1 Separating equilibria

In a separating equilibrium, both types of incumbent choose two different actions in the first period. Thus, the first period pricing policies fully reveal the type of the incumbent to the entrant. Denote by P_s^R and P_{ns}^R the pricing policy of types s and ns, respectively, in a separating equilibrium. There are two necessary conditions for a separating equilibrium: that type s does not want to pick the equilibrium pricing policy of type ns and vice-versa. We then complete the description of the equilibrium by choosing beliefs that are off the equilibrium path (i. e. for prices that differ from the two potential equilibrium pricing policies) and that discourage the two types of incumbent from deviating from their equilibrium pricing policy.

[14] There is a third kind in which the incumbent uses a mixed strategy. In this work we analyze only pure-strategy sequential equilibria.

Lemma 1. *In a separating equilibrium, incumbent type s charges the static monopoly pricing policy* $P_s^R = P_s^m \equiv (p_1^m, p_2^m)$*, that is, it price discriminates as it would under complete information.*

Proof. In a separating equilibrium, the message sent in the first period reveals the type of incumbent to the entrant. Hence, the pre-entry behaviour of the incumbent type s induces entry. But if there is entry the best type s can do is to choose the monopoly static price in each submarket, p_1^m and p_2^m; if it did not, it could increase its first period profit without changing the second period profit. □

The non-segmented market incumbent, type ns, will attempt to distinguish itself from the incumbent type s by choosing a suitable pricing policy $P_{ns}^R \equiv (p^r, p^r)$. A way to become distinguished from type s would be to charge a price sufficiently below its monopoly price. However, it is also possible for type ns to separate itself from type s by increasing its price. Next, we analyze the individual rationality and incentive compatibility conditions that must be satisfied in a separating equilibrium.

– Type s incentive-compatibility constraint. It must be true that the segmented market incumbent is unwilling to mimic the choice of the incumbent type ns; that is, type s makes more profit by charging its monopoly prices and allowing entry than by choosing the equilibrium strategy of type ns (a pricing policy P_{ns}^R) and deterring entry. Thus, a necessary condition is:

$$\Pi_s^m + \delta \Pi_s^I \geq \Pi_s(P_{ns}^R) + \delta \Pi_s^m$$

or equivalently,

$$\Pi_s^m - \Pi_s(P_{ns}^R) \geq \delta(\Pi_s^m - \Pi_s^I) \tag{1}$$

– Type ns individual rationality constraint. The incumbent type ns must be better (or equally well) off playing its equilibrium strategy, P_{ns}^R, than choosing its monopoly strategy in the first period and facing entry in the second one. Therefore, we must have

$$\Pi_{ns}(P_{ns}^R) + \delta \Pi_{ns}^m \geq \Pi_{ns}^m + \delta \Pi_{ns}^I$$

or equivalently,

$$\Pi_{ns}^m - \Pi_{ns}(P_{ns}^R) \leq \delta(\Pi_{ns}^m - \Pi_{ns}^I) \tag{2}$$

As the incumbent type ns uses a uniform pricing policy, we shall express the incumbent's profit sometimes in terms of a single price, $\Pi_s(p)$ *and* $\Pi_{ns}(p)$. To make things interesting, we assume that there is no separating equilibrium in which each type behaves as in a full-information context; i.e., the type s incumbent would wish to pool at the monopoly pricing policy of type ns, $P_{ns}^m \equiv (p_{ns}^m, p_{ns}^m)$:

$$\Pi_s^m - \Pi_s(p_{ns}^m) < \delta(\Pi_s^m - \Pi_s^I) \tag{3}$$

Given the model assumptions, this constraint is satisfied with $\delta = 1$. Hence, assuming (3) is equivalent to assuming δ high enough: $\delta > \overline{\delta}$, where $\overline{\delta}$ is such that (3) is satisfied with equality.

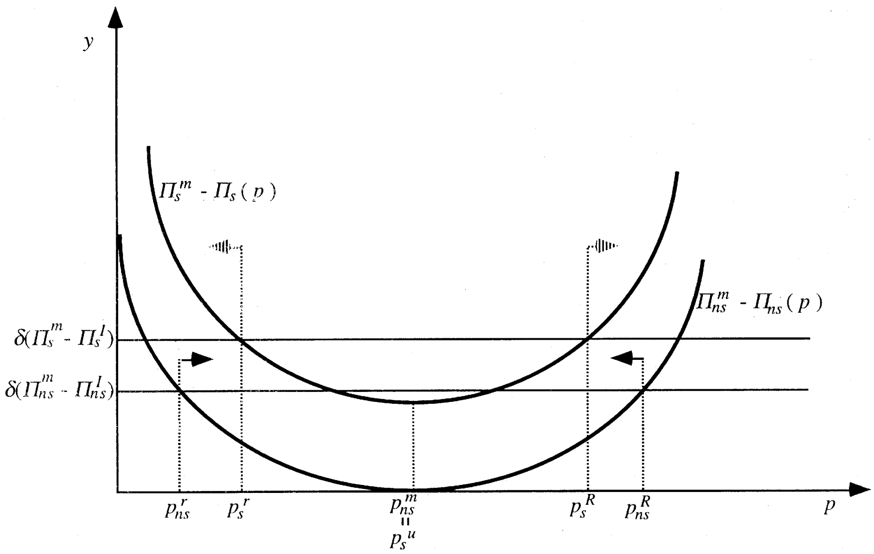

Fig. 1. Individual rationality and incentive compatibility constraints

We do not impose a single crossing condition; this makes it possible for type *ns* to be distinguished from type *s* by raising or by reducing its price. Curves $y = \Pi_s^m - \Pi_s(p)$ and $y' = \Pi_{ns}^m - \Pi_{ns}(p)$ do not cross in $\{y, p\}$ space. Note that as $\Pi_s^m > \Pi_{ns}^m$ and $\Pi_s(p) = \Pi_{ns}(p)$ then curve y is above y' for any p. Furthermore, type *s* benefits more from remaining a monopolist than type *ns* does. So that, $\Pi_s^m - \Pi_s^I > \Pi_{ns}^m - \Pi_{ns}^I$.[15] Denote by p_s^r and p_s^R the prices satisfying type *s* incentive compatibility constraint, (1), with equality (that is, the two roots of the second degree equation). Thus, this condition is satisfied for $p \le p_s^r$ and $p \ge p_s^R$. Scratched arrows in Fig. 1 delimit price intervals in which that condition is satisfied. Denote by p_{ns}^r and p_{ns}^R the prices satisfying (2) with equality, the type *ns* individual rationality constraint. Shaded arrows, in Fig. 1, delimit the price interval where this condition is satisfied, $p \in [p_{ns}^r, p_{ns}^R]$.

Notice that, from Fig. 1, in the intervals $[p_{ns}^r, p_s^r]$ and $[p_s^R, p_{ns}^R]$ the type *s* incentive compatibility and the type *ns* individual rationality constraints are satisfied simultaneously. Thus prices, p^r, belonging to such intervals can be made part of a separating equilibrium. Hence, to separate, the incumbent type *ns* must charge a price sufficiently below or sufficiently above its monopoly price. Prices p_s^r and p_s^R are called the *least-cost* separating prices because the incumbent type *ns* would prefer p_s^r or p_s^R to all potential separating prices, the closest to its monopoly price. Therefore, type *ns* can become separate from type *s* by reducing or by raising its price. The following proposition states our first result in this section.

[15] Notice that this condition is equivalent to $\Pi_s^m - \Pi_{ns}^m > \Pi_s^I - \Pi_{ns}^I$; that is, a monopolist benefits more from price discrimination than a duopolistic firm does. For example, under Cournot competition $\Pi_s^m - \Pi_{ns}^m = \frac{9}{4}(\Pi_s^I - \Pi_{ns}^I)$.

Proposition 1. *There exists a multiplicity of separating equilibria; in all of them entry occurs exactly when it would have occurred under symmetric information:*

$$\{(P_t^R)_{t=s,ns} | P_s^R = P_s^m \equiv (p_1^m, p_2^m),\ P_{ns}^R \equiv (p^r, p^r), p^r \in [p_{ns}^r, p_s^r] \cup [p_s^R, p_{ns}^R]\}$$
$$e(P_s^m) = 1;\ e(P_{ns}^R) = 0;\ e(P) = 1 \text{ if } P \notin \{P_s^m, P_{ns}^R\}$$
$$\mu(P_s^m) = 1;\ \mu(P_{ns}^R) = 0;\ \mu(P) = 1 \text{ if } P \notin \{P_s^m, P_{ns}^R\}$$

Proof. The necessary conditions for a separating equilibrium are that the incumbent type s chooses the pricing policy P_s^m (by lemma 1) and the incumbent type ns selects a pricing policy $P_{ns}^R \equiv (p^r, p^r)$, $p^r \in [p_{ns}^r, p_s^r] \cup [p_s^R, p_{ns}^R]$ in the first period. Notice that if $p^r \in [p_{ns}^r, p_s^r] \cup [p_s^R, p_{ns}^R]$, constraints (1) and (2) are satisfied simultaneously. In the Appendix we show that $p_s^r > p_{ns}^r$ and $p_{ns}^R > p_s^R$ so that the two disjoint intervals of separating prices are not empty. The entrant's optimal strategy, given its posterior beliefs, $\mu(P_s^m) = 1$ and $\mu(P_{ns}^R) = 0$, is entry if the incumbent reveals itself as type s and no entry if it reveals itself as being type ns. The beliefs off the equilibrium path are $\mu(P) = 1$ if $P \notin \{P_s^m, P_{ns}^R\}$; that is, if it observes a pricing policy $P \notin \{P_s^m, P_{ns}^R\}$, the entrant believes that the incumbent is type s and decides to entry. These beliefs deter both types from deviating from their equilibrium prices, and thus our necessary conditions are also sufficient. □

The following conclusions hold for these separating equilibria. Entry occurs exactly when it would have occurred under symmetric information. That is, there is entry only when the entrant observes price discrimination in period 1. Moreover, although when the incumbent is type ns there is no entry, the price is lower (or higher) than in the complete information case, therefore, it has to sacrifice short-run profits to signal its type. That is a type ns incumbent can separate using limit pricing or overlimit pricing. We have obtained a continuum of separating equilibria. In Sect. 4, we use some refinement criteria, commonly used, to choose among them.

3.2 Pooling equilibria

In a pooling equilibrium, both types of incumbent send the same message in the first period: $P_s = P_{ns} = P^p \equiv (p^p, p^p)$. Therefore, the entrant learns nothing about the incumbent's type from observing first period pricing policies. Hence, its posterior beliefs are identical to its prior beliefs: $\mu(P^p) = \mu^o$ (where P^p is a pooling pricing policy).

Lemma 2. *The existence of pooling (not revealing) equilibria requires that the expected profits of the entrant given its prior beliefs be non positive:*

$$\mu^o \Pi_s^E + (1 - \mu^o)\Pi_{ns}^E \leq 0 \qquad (4)$$

Proof. Assume that condition (4) is violated. Then, at the pooling pricing policy, the potential entrant makes a positive expected profit if it enters because its posterior beliefs are the same as its prior beliefs. But this means that entry is not deterred, so that the two types of incumbent cannot but choose their static monopoly pricing policy. It must hold that $\mu^{o} \leq \frac{-\Pi^{E}_{ns}}{\Pi^{E}_{s}-\Pi^{E}_{ns}}$. As $\Pi^{E}_{ns} < 0$ and $\Pi^{E}_{s} > 0$, then $0 < \mu^{o} < 1$. □

A necessary condition for a pricing policy $P^{p} \equiv (p^{p}, p^{p})$ to be a pooling equilibrium price is that neither of the types wants to charge its monopoly pricing policy . If one of them does so it allows entry at worst. Thus, $P^{p} \equiv (p^{p}, p^{p})$ must satisfy the following two individual rationality constraints:

$$\Pi^{m}_{s} - \Pi_{s}(p^{p}) \leq \delta(\Pi^{m}_{s} - \Pi^{I}_{s}) \tag{5}$$

$$\Pi^{m}_{ns} - \Pi_{ns}(p^{p}) \leq \delta(\Pi^{m}_{ns} - \Pi^{I}_{ns}) \tag{6}$$

These conditions are satisfied for prices $p^{p} \in [p^{r}_{s}, p^{R}_{s}]$. Note also that the monopoly price of type *ns* and the uniform monopoly price of type *s* belong to such an interval. The following proposition characterizes pooling equilibria.

Proposition 2. *There exists a multiplicity of pooling equilibria such that:*

$$\{(P^{P}_{t})_{t=s,ns} | P^{P}_{s} = P^{p} \equiv (p^{p}, p^{p}),\ P^{P}_{ns} = P^{p} \equiv (p^{p}, p^{p}),\ p^{p} \in [p^{r}_{s}, p^{R}_{s}]\}$$
$$e(P^{p}) = 0; e(P) = 1 \quad if \quad P \neq P^{p}$$
$$\mu(P^{p}) = \mu^{o} \quad and \quad \mu(P) = 1 \quad if \quad P \neq P^{p}$$

Proof. See lemma 2 and conditions (5) and (6). □

Again, the beliefs off the equilibrium path are that the deviation from P^{p} comes from type s. Notice that in a pooling equilibrium a type s incumbent chooses a uniform pricing policy to deter entry. The entrant learns nothing from observing the first period pricing policy of the incumbent and, therefore, the uniform pricing strategy would serve to hide relevant information about market profitability.

To obtain sequential equilibria, separating and pooling, we have assumed that at any pricing policy different from the expected equibrium pricing policy of the incumbent type s the entrant infers $t = s$ with certainty. This system of beliefs is the least favourable from the point of view of the incumbent firm and will therefore support the largest set of sequential equilibria. In the next section we refine the set of sequential equilibria by restricting posterior beliefs.

4 Refinements of sequential equilibria

In addition to the elimination of weakly dominated strategies we shall consider the following criteria: intuitive criterion (Cho and Kreps 1987), divinity (Banks and Sobel 1987; D1 in Cho and Kreps 1987) and universal divinity (Banks and Sobel 1987) and Never Weak Best Response (NWBR) (Kohlberg and Mertens

1986; Cho and Kreps 1987).[16] Cho and Sobel (1990) identify a class of signalling games in which the D1 criterion is equivalent to universal divinity and the NWBR criterion: monotonic signalling games. Such games satisfy the following monotonicity property: "all sender types have identical preferences over the receiver's best responses (in pure and mixed strategies)". When the receiver has only two pure-strategy best responses, monotonicity holds whenever all the sender types agree on their ranking of the pure-strategy best responses of the receiver (see Cho and Sobel 1990). The model in Sect. 2 belongs to this class of signalling games because the potential entrant has only two pure-strategy best responses (enter and not enter) and the two types of incumbent want the potential entrant not to enter. So, we consider only weak dominance, the intuitive criterion and the D1 criterion.[17] The Bayesian updating of beliefs cannot be applied to those signals sent with probability zero in equilibrium. The above refinements try to reduce the multiplicity of equilibria by imposing some "reasonable" restrictions on beliefs following a zero-probability event. The receiver is required to assign zero weight to the types of sender that are unlikely to send those signals.

Lemma 3. *Separating equilibria with prices lower than p_s^r, or higher than p_s^R, do not verify weak dominance criterion.*

Proof. The argument is as follows. Fix a separating equilibrium with $p < p_s^r$ and consider a message out of the equilibrium path: i.e. $p_s^r - \varepsilon$. Type s would not have incentives to send that signal because it obtains more profits by choosing its monopoly pricing policy and allowing entry (see condition (1)). Therefore, the entrant should not put weight on type s after observing $p_s^r - \varepsilon$. Therefore, posterior beliefs after $P^\varepsilon \equiv (p_s^r - \varepsilon, p_s^r - \varepsilon)$ should be $\mu(P^\varepsilon) = 0$ and entry is deterred. Then, type ns would want to deviate to $p_s^r - \varepsilon$. Notice that prices below p_s^r are weakly dominated for the type s incumbent. The reasoning is similar to high-price separating equilibria with $p > p_s^R$. □

As the intuitive criterion is stronger than the elimination of weakly dominated strategies, the above equilibria will not satisfy the former criterion. Notice that the least-cost separating equilibria and pooling equilibria satisfy the intuitive criterion. Next we show how criterion D1 selects among equilibria; the following proposition states the main result of this section.

Proposition 3. *The only sequential equilibrium satisfying criterion D1 is the efficient pooling equilibrium, at $p_{ns}^m (= p_s^u)$, for any $\delta > \overline{\delta}$.*

Proof. See Appendix 2.

[16] The intuitive criterion has been applied to a lot of economic problems because it satisfies two interesting properties. First, the set of equilibria satisfying this refinement is always non empty in the set of signalling games. Second, it is a superset of the strategically stable equilibria set of Kohlberg and Mertens (1986). Cho and Sobel (1990) show that criterion D1 is equivalent to strategic stability in monotonic signalling games.

[17] The most restrictive of them is criterion D1 and the least restrictive is weak dominance. Thus, if an equilibrium satisfies criterion D1 it will also satisfy the intuitive criterion. See Cho and Sobel (1990) and Cho and Kreps (1987).

Thus, in the D1 equilibrium, the incumbent type s uses the uniform pricing policy in order to discourage entry. So this pricing policy, by not revealing new information on the actual market profitability, would serve as an entry deterrence device. Thus, an incumbent firm may decide not to price discriminate between its customers in order not to reveal its superior information on market demand composition to a potential entrant. Uniform pricing may allow an incumbent to distort the entrant's inference process and deter entry by reducing the expected profits.

5 Concluding remarks

If an incumbent posseses private information on market demand composition, it is aware that its pre-entry pricing policy may affect the probability of entry. Under price discrimination, it is sending signals, to a potential entrant, that there exists in the market a big potential for extracting customers' surplus. In particular, it gives information on the existence of different groups of customers that differ in demand elasticities and that may be profitability separated. Thus, the incumbent will have an incentive to charge a single price in order to hide the degree of heterogeneity between its customers and, thus, the actual market profitability. We have considered the case of third degree price discrimination but the idea seems applicable to other forms of price discrimination.

We show, in this paper, that uniform price policies may have informational advantages over third degree price discrimination for a monopolist facing a threat of entry. We consider a signalling game with a multiplicity of sequential equilibria. The main result is that the unique sequential equilibrium satisfying criterion D1 is the efficient pooling equilibrium. In this equilibrium, the segmented market incumbent uses the uniform price policy to convey bad news to the potential entrant about its profitability in the market.

Appendix

Existence of separating equilibria

We are going to prove that $p_s^r > p_{ns}^r$ and $p_{ns}^R > p_s^R$, i.e., the intervals of separating prices are not empty. Denote by p_{ns}^r and p_{ns}^R the prices satisfying [2], the individual rationality constraint of type ns, with equality. That is, $\Pi_{ns}^m - \Pi_{ns}(p_{ns}) = \delta(\Pi_{ns}^m - \Pi_{ns}^I)$ where $p_{ns} \in \{p_{ns}^r, p_{ns}^R\}$ and $\Pi_{ns}'(p_{ns}^r) > 0$ and $\Pi_{ns}'(p_{ns}^R) < 0$ if $p_{ns}^r < p_{ns}^m < p_{ns}^R$. Given that $\Pi_s(p) = \Pi_{ns}(p)$ and $\Pi_{ns}(p_{ns}) = \Pi_{ns}^m - \delta(\Pi_{ns}^m - \Pi_{ns}^I)$, then $\Pi_s^m - \Pi_s(p_{ns}) = \Pi_s^m - \Pi_{ns}^m + \delta(\Pi_{ns}^m - \Pi_{ns}^I)$. Thus, the incentive compatibility constraint of type s is satisfied strictly given that $\Pi_s^m - \Pi_{ns}^m > \delta[(\Pi_s^m - \Pi_{ns}^m) - (\Pi_s^I - \Pi_{ns}^I)]$. Let p_s^r and p_s^R be the prices such that the incentive compatibility constraint of type s, (1), is satisfied with equality. As $p_s^r < p_{ns}^m < p_s^R$ (following assumption (3)), the above reasoning implies $p_s^r > p_{ns}^r$ and $p_{ns}^R > p_s^R$. Hence, there are two disjoint intervals of separating prices, $[p_{ns}^r, p_s^r]$ and $[p_s^R, p_{ns}^R]$. □

Proof of Proposition 3

In order to apply criterion D1 we need some definitions and properties. Let $\frac{\Pi_t'(p)}{\delta(\Pi_t^m-\Pi_t^I)}$ be the marginal rate of substitution of price increases in period 1 for the gain obtained by remaining a monopolist in period 2 for the type t, $t = s, ns$. Note that as $\Pi_s'(p) = \Pi_{ns}'(p)$ for all p, these marginal rates are equal for both types of incumbent at p_{ns}^m where marginal profits are zero. Given that $\Pi_s^m - \Pi_s^I > \Pi_{ns}^m - \Pi_{ns}^I$, we can distinguish the following price intervals:

$$
\begin{aligned}
&- c \leq p < p_{ns}^m \quad && \frac{\Pi_s'(p)}{\delta(\Pi_s^m - \Pi_s^I)} < \frac{\Pi_{ns}'(p)}{\delta(\Pi_{ns}^m - \Pi_{ns}^I)}, \quad && \Pi_t' > 0,\ t = s, ns.\\
&- p = p_{ns}^m && \frac{\Pi_s'(p)}{\delta(\Pi_s^m - \Pi_s^I)} = \frac{\Pi_{ns}'(p)}{\delta(\Pi_{ns}^m - \Pi_{ns}^I)}, && \Pi_t' = 0,\ t = s, ns. \qquad \text{(A1)}\\
&- p > p_{ns}^m, && \frac{\Pi_s'(p)}{\delta(\Pi_s^m - \Pi_s^I)} > \frac{\Pi_{ns}'(p)}{\delta(\Pi_{ns}^m - \Pi_{ns}^I)}, && \Pi_t' < 0,\ t = s, ns.
\end{aligned}
$$

First, we show that the least-cost separating equilibria do not satisfy criterion D1. Consider the (low price) separating equilibrium at p_s^r. In this equilibrium, the incumbent type s price discriminates (setting the static monopoly prices) and the incumbent type ns prices uniformly at p_s^r. Consider the message $p_s^r+\varepsilon$ off the equilibrium path. If the incumbent type ns has an incentive to deviate whenever the incumbent type s has a weak incentive to deviate, then the beliefs of the potential entrant should not assign positive weight to type s at the information set $p_s^r + \varepsilon$. That is, criterion D1 tells us that the potential entrant's posterior beliefs should be $\mu(p_s^r + \varepsilon) = 0$; but, then, type ns has an incentive to deviate to $p_s^r+\varepsilon$ because entry is deterred and, thus, its profit is increased. To verify this we consider the sets $D(s|p_s^r+\varepsilon)$, $D^o(s|p_s^r+\varepsilon)$, $D(ns|p_s^r+\varepsilon)$ and $D^o(ns|p_s^r+\varepsilon)$ (See, for example, in Cho and Sobel (1990) the definitions given for these sets). The least-cost separating equilibrium profit of the incumbent type s is: $\Pi_s^* = \Pi_s^m + \delta\Pi_s^I$. We consider the set of mixed-strategy best responses of the potential entrant to $p_s^r + \varepsilon$ such that the incumbent type s obtains more expected profit by playing $p_s^r+\varepsilon$ than by following its equilibrium strategy; that is the set $D(s|p_s^r+\varepsilon)$. Let r be the potential entrant's mixed strategy "entry with probability k, no entry with probablility $1 - k$". If this strategy belongs to $D(s|p_s^r + \varepsilon)$ then: $\Pi_s^m + \delta\Pi_s^I < \Pi_s(p_s^r + \varepsilon) + \delta[(1 - k)\Pi_s^m + k\Pi_s^I]$. Rearranging: $k < \frac{\Pi_s(p_s^r+\varepsilon)-\Pi_s(p_s^r)}{\delta(\Pi_s^m-\Pi_s^I)} = h$. Let r' be the potential entrant's mixed strategy "entry with probability k', no entry with probability $1 - k'$". If $r' \in D(ns|p_s^r + \varepsilon)$ then: $\Pi_{ns}^* = \Pi_{ns}(p_s^r) + \delta\Pi_{ns}^m < \Pi_{ns}(p_s^r + \varepsilon) + \delta[(1 - k')\Pi_{ns}^m + k'\Pi_{ns}^I]$.Therefore: $k' < \frac{\Pi_{ns}(p_s^r+\varepsilon)-\Pi_{ns}(p_s^r)}{\delta(\Pi_{ns}^m-\Pi_{ns}^I)} = h'$. As $p_s^r < p_{ns}^m$ (and ε low enough) then, using (A1), $h' > h$ and $1-h > 1-h'$. Thus: $D(s|p_s^r + \varepsilon) \cup D^o(s|p_s^r + \varepsilon) \subset D(ns|p_s^r + \varepsilon)$. Following the previous argument, it is easy to check that the pooling equilibria with $p^p < p_{ns}^m$ do not meet criterion D1.

We next show that pooling equilibria with $p^p > p_{ns}^m$ do not meet criterion D1. Consider the mixed-strategy best responses by the entrant to $p^p - \varepsilon$ such that the type s incumbent obtains more expected profit by playing $p^p - \varepsilon$ than by its equilibrium strategy. Let r be the potential entrant's mixed strategy "entry with probability k, no entry with probablility $1-k$". If this strategy belongs to $D(s|p^p-\varepsilon)$, then: $\Pi_s(p^p)+\delta\Pi_s^m < \Pi_s(p^p-\varepsilon)+\delta[(1-k)\Pi_s^m+k\Pi_s^I]$. Rearranging: $k < \frac{\Pi_s(p^p-\varepsilon)-\Pi_s(p^p)}{\delta(\Pi_s^m-\Pi_s^I)} = h$. If $r' \in D(ns|p^p-\varepsilon)$, where r' is defined as above, then: $\Pi_{ns}(p^p)+\delta\Pi_{ns}^m < \Pi_{ns}(p^p-\varepsilon)+\delta[(1-k')\Pi_{ns}^m+k'\Pi_{ns}^I]$. Consequently, $k' < \frac{\Pi_{ns}(p^p-\varepsilon)-\Pi_{ns}(p^p)}{\delta(\Pi_{ns}^m-\Pi_{ns}^I)} = h'$. Note that to $p^p > p_{ns}^m = p_s^u$ the marginal profits of both types of incumbent are negative and $\frac{\Pi_s'(p)}{\delta(\Pi_s^m-\Pi_s^I)} > \frac{\Pi_{ns}'(p)}{\delta(\Pi_{ns}^m-\Pi_{ns}^I)}$. Hence, $h' > h$ and $D(s|p^p-\varepsilon)\cup D^o(s|p^p-\varepsilon) \subset D(ns|p^p-\varepsilon)$. Therefore the posterior beliefs of the potential entrant should be $\mu(p^p-\varepsilon)=0$; but, then, there is no entry and, thus, the type ns incumbent would have an incentive to deviate to $p^p-\varepsilon$. Consequently, pooling equilibria with $p^p > p_{ns}^m = p_s^u$ do not satisfy criterion D1. It is easy to show, by a similar reasoning, that high-price separating equilibria do not satisfy criterion D1.

Finally, we demonstrate that the efficient pooling equilibrium with price p_{ns}^m satisfies criterion D1. Note that in this equilibrium the incumbent type ns uses its static monopoly price and, furthermore, entry is deterred. So that, $D(ns|m) = D^o(ns|m) = \emptyset$ to any m out of the equilibrium path and, thus, $D(ns|m)\cup D^o(ns|m) \subset D(s|m)$ when $D(s|m) \neq \emptyset$ for some m (say, $P_s^R = P_s^m \equiv (p_1^m, p_2^m)$). Consequently, for any out-of-equilibrium-path-message m, the potential entrant's posterior beliefs should be $\mu(m)=1$; but that supports the equilibrium. Hence, such equilibrium meets criterion D1. Thus, the only D1 equilibrium is the efficient pooling equilibrium. □

References

Aguirre, I. (1996a) Uniform pricing: Good or bad news about market profitability?, *S.E.E.D.S.* D.P.149

Aguirre, I. (1996b) Most-Favoured-Customer Pricing Policy as an Entry Deterrence Device, *S.E.E.D.S.* D.P.151

Aguirre, I., Espinosa, M.P., Macho, I. (1998) Strategic Entry Deterrence through Spatial Price Discrimination, *Regional Science and Urban Economics* 28, 297–314

Anderson, S.P., Neven D. (1991) Cournot Competition Yields Spatial Agglomeration. *International Economic Review* 32: 793–808

Bagwell, K., Ramey, G. (1988) Advertising and Limit Pricing. *RAND Journal of Economics* 19:59–70

Bagwell, K., Ramey, G. (1990) Advertising and Pricing to Deter or Accommodate Entry when Demand Is Unknown. *International Journal of Industrial Organization* 8:93–113

Bain, J.S. (1949) A Note on Pricing in Monopoly and Oligopoly. *The American Economic Review*: 448–464

Banks, J.S., Sobel, J. (1987) Equilibrium Selection in Signaling Games. *Econometrica* 55:647–661

Beane, T.D., Ennis, D.M. (1987) Market Segmentation: a Review. *European Journal of Marketing* 21:20–42

Butz, D.A. (1990) Durable-good monopoly and best price provisions. *The American Economic Review* 80:1062–1076

Cho, I., Kreps, D.M. (1987) Signaling Games and Stable Equilibria. *Quarterly Journal of Economics* 102:179–221

Cho, I., Sobel, J. (1990) Strategic Stability and Uniqueness in Signaling Games. *Journal of Economic Theory* 50:381–413

Cooper, T.E. (1986) Most-Favoured-Customer Pricing and Tacit Collusion. *Rand Journal of Economics* 17:377–388 von der Fehr, N.-H.M. (1992) How Entry Threats Induce Slack. *International Journal of Industrial Organization* 10:231–249

Hamilton, J.H., Thisse, J.-F., Weskamp, A. (1989) Spatial discrimination: Bertrand vs. Cournot in a model of location choice. *Regional Science and Urban Economics* 19:87–102

Harrington, J.E., Jr. (1986) Limit Pricing when the Potential Entrant Is Uncertain of Its Cost Function. *Econometrica* 54(2):429–437

Hobbs, B.F. (1986) Mill pricing versus spatial price discrimination under Bertrand and Cournot spatial competition. *Journal of Industrial Economics* XXXV:173–191

Holmes, T.J. (1989) The effects of third-degree price discrimination in oligopoly. *The American Economic Review* 79: 244–250

Kohlberg, E., Mertens, J.-F. (1986) On the Strategic Stability of Equilibria. *Econometrica* 54:1003–1037

Krugman, P.R. (1989) Industrial Organization and International Trade. In: Schmalensee, R., Willig, R.D. (eds.) *Handbook of Industrial Organization*, vol. I, Elsevier Science Publishers B. V

Mailath, G.J. (1991) The Impact of Asymmetric Information on Entry Deterrence: an Example. *Economics Letters* 35:333–338

Masson, R.T., Shaanan, J. (1982) Stochastic-Dynamic Limiting Pricing: an Empirical Test. *The Review of Economics and Statistics* 64:413–423

Masson, R.T., Shaanan, J. (1987) Optimal Oligopoly Pricing and the Threat of Entry. *International Journal of Industrial Organization* 5:323–339

Matthews, S.A., Mirman, L.J. (1983) Equilibrium Limit Pricing: the Effects of Private Information and Stochastic Demand. *Econometrica* 51:981–996

Milgrom, P., Roberts, J. (1982) Limit Pricing and Entry under Incomplete Information: an Equilibrium Analysis. *Econometrica* 50:443–459

Neven, D., Phlips, L. (1985) Discriminating Oligopolists and Common Markets. *The Journal of Industrial Economics* XXXIV:133–149

Phlips, L. (1983): *The Economics of Price Discrimination*, Cambridge University Press

Roberts, J. (1987) A Signaling Model of Predatory Pricing. *Oxford Economic Papers*, Suppl 38:75–93

Salop, S.C. (1979) Strategic Entry Deterrence. *The American Economic Review* 69: 335–338

Salop, S.C. (1986) Practices that (credible) facilitate oligopoly co-ordination. In: Stiglitz, S., Mathewson, F. (eds.) *New developments in the analysis of market structure*. MIT Press, Cambridge, MA

Smiley, R. (1988) Empirical Evidence on Strategic Entry Deterrence. *International Journal of Industrial Organization* 6:167–180

Tirole, J. (1988): *The Theory of Industrial Organization*, MIT Press, Cambridge, MA

Varian, H. (1989) Price Discrimination. In: Schmalensee, R., Willig, R.D. (eds.) *Handbook of Industrial Organization*, vol. I. Elsevier Science Publishers B. V