On The Strategic Choice of Spatial Price Policy

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Price discrimination emerges as the unique equilibrium outcome in games with either simultaneous choice of policy and price or sequential choice in which firms may commit first to uniform mill pricing before the actual market stage. Our results are used to analyze some common business practices that arise in geographical pricing, like the basing point system, and in the pricing of varieties or options from a base product in a product differentiation context.

In any industry, current business practices are not only the result of an adaptation by firms to particular technological or institutional conditions but also reflect, or are the instruments of, a *strategic* positioning of firms in the market.[1] The specific price policies that firms follow are obviously one of the most important business practices in any market environment. Although their strategic importance is widely recognized in the business literature, perhaps somewhat surprisingly, the economics literature in general has not paid enough attention to the detail of specific pricing methods and, consequently, has not been able to provide convincing explanations of the incentive structure that lies behind certain price policies. In this paper, we would like to present some very simple game-theoretic models which are naturally related to some pricing policies found in geographical or product differentiation contexts. Let us begin by describing some of these policies.

In a geographical context, examples of alternative pricing methods are: (i) the zone price system, under which a specific delivered price is charged to all buyers located in a given region, such as for plasterboard in the United Kingdom or cement in Belgium; (ii) the (single) basing point system, in which the delivered price equals a base price plus the cost of shipping to the place of delivery from a given basing point that need not be where the seller is actually located, such as the Pittsburgh-plus system used in the steel industry in the United States until the mid-1920s or the Portland-plus system used for plywood in the United States until the 1970s; (iii) uniform free on board (FOB) prices, in which the delivered price equals the mill price—the same for all customers—plus the actual transport costs.[2]

In a product differentiation context, the choice of a price policy is, in a certain sense. closely related to the firm's variety offer. For example, car manufacturers may decide to provide a single standardized product to satisfy a hypothetical average consumer, as shown by the historical examples of the Ford T and the Volkswagen's "Beetle." Alternatively, they may offer a basic product with a series of options with different price tags such as most car manufacturers currently stock.[3] The first case corresponds to a uniform (FOB) price policy, in which the manufacturers leave the options to indepen-

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[1]We are grateful to Jonathan Hamilton, Louis Phlips, Kriss Sjoblom, and an anonymous referee for helpful comments. The authors' research was supported respectively by the National Science Foundation grant no. SES-8502886 to the University of Pennsylvania and by the Research Fund, University of Pennsylvania.

[2]See F. M. Scherer, 1980, ch. 11; L. Phlips (1983), ch. 1, and M. L. Greenhut et al., 1987, for a detailed description of spatial pricing policies. Actual pricing patterns are studied in Greenhut et al., 1980, and Greenhut, 1981.

[3]The number of options may be very large indeed. The different makes of the Ford Escort, bumper-to-bumper, would cover the distance between Paris and Brussels, that is, 230 km (see L. Augier and J.-P. Icikovics, 1982).

dent producers.[4] The second case, in which the options are under the manufacturers' control, typically involves discriminatory pricing.

A basic question, which interests both the analyst and the policymaker, is to determine what kind of price policy the government should encourage. In particular, is price discrimination necessarily evidence of lack of competition and harmful to the consumers?

In a geographical context, there is price discrimination when firms do not set uniform FOB prices, that is, when the difference between delivered prices at two distinct locations does not equal the transport cost between them. In a product differentiation context, we say that there is price discrimination if two varieties are sold at different base prices, that is, prices corrected by the cost of the corresponding options. Many countries have legislated against price discrimination defined as charging different prices to different buyers of the same goods. Obviously, the problem is to know whether the goods sold are the same since a given physical good is a different economic good depending on location, date of delivery, or service features, for example. In the United States, the Robinson-Patman Act prohibits charging different prices to different buyers of "goods of like grade and quality" where the result "may be substantially to lessen competition or then to create a monopoly in any line of commerce, or to injure, destroy, or prevent competition with any person who either grants or knowingly receives the benefit of such discrimination, or with customers of either of them" (see Scherer, 1980, p. 572). In the United Kingdom, the now-abolished Price Commission has favored uniform FOB pricing as shown, for example, by the series of reports published in 1978. In any case, it has been claimed that the motivation for these laws was more to limit than to promote competition (see, for example, Scherer, 1980, ch. 21) and that they may have perverse effects (see, for example, M. Schwartz, 1986).

The importance of price policies for the firms and the public authority is clear. Nevertheless, there exist very few models which rationalize in economic terms specific price policies, like the basing point system for example, or which explain the strategic incentives that firms may have to price discriminate. A great deal of attention has been paid to the issue of uniform versus discriminatory pricing in the general literature on *monopolistic price discrimination* (see, for example, W. Y. Oi, 1971; A. C. Pigou, 1920; J. Robinson, 1933; R. Schmalensee, 1981) and in the theory of *spatial monopoly* (see M. J. Beckmann, 1976; Greenhut and H. Ohta, 1972; W. L. Holahan, 1975, for example). The general conclusion is that a monopolist can secure higher profits by price discriminating. On the other hand, there is no such clear-cut statement for the consumers. Very often (and this is true in the spatial monopoly case), they are partitioned under discriminatory pricing into those who pay a higher price and those who pay a lower price. However, as a whole, consumers often prefer uniform FOB pricing.

In contrast, much less attention has been devoted to the choice of a price policy in an oligopolistic environment in which strategic considerations are of primary importance.[5] The purpose of this paper is to contribute to the analysis of this issue. More specifically, we want to examine (i) the incentives that arise in spatial competition for firms to price discriminate or price uniformly, and (ii) the consequences of the price policy choice for firms and consumers.

In our paper, we consider a duopoly in which each firm is already located in some (geographical or characteristics) space and has to choose whether to price discriminate or not, taking the strategic effects of its

[4] Alfred P. Sloan, Jr., in the chapter about styling in his book "*My Years with General Motors*" talks about the custom body shop of Don Lee of Los Angeles, CA, "in which he built special bodies on both foreign and American chassis for Hollywood movie stars and wealthy people of California" (A. Sloan, 1972, p. 312).

[5] Most contributions in spatial competition take the pricing policy as given. A notable exception is J. Greenhut and Greenhut (1975). However, these authors study spatial discrimination with quantity-setting firms. Here, we consider price-setting firms. A comparison of these two forms of spatial discrimination is contained in J. Hamilton et al. (1987).

choice into account. We deal, first, with the simultaneous choice of policy and price (Section II) and, second, with the case where firms may commit to a price policy first and then compete in prices contingent on the chosen policies (Section III).

When firms do not commit to a price policy, they compete with unrestricted price schedules, choosing a (delivered) price for every location. We are interested in knowing whether uniform (FOB) pricing can arise in equilibrium in such a situation. Under some circumstances, firms do commit themselves to a specific price policy. Such is the case, for example, in the basing point system. Suppose that there are two firms established at two different places and one basing point. The firm at the basing point is a price leader and announces a (uniform) base price. The other firm reacts optimally to the leader's choice by matching the full price (base price plus transport cost) wherever possible, that is, by price discriminating. In this situation, the leader prices uniformly and the follower price discriminates. In other words, the leader is committed to uniform FOB pricing. One question we want to answer is then: Can this system be rationalized in a context in which there is no scope for collusion, that is, in a two-stage game where, first, firms may commit to certain pricing policies, and then, compete in prices according to the selected polices?

In both the simultaneous no-commitment and the sequential commitment cases, *price discrimination* (by all firms in the market) *emerges as the unique equilibrium outcome*, even though it may well be that firms would make more profits by following a uniform price policy. This is so because spatial discriminatory pricing gives more flexibility to a firm to respond to its rival's actions. But then firms may get trapped into a Prisoner's Dilemma-type situation and end up with lower profits due to the intense competition unleashed. Contrary to general belief, uniform (FOB) pricing is therefore *not* evidence of a more competitive environment.[6]

[6]See also G. Norman (1983).

With simultaneous choice of policy and price the result is very general in terms of the characteristics space, density of demand, and transportation cost schedules which are allowable. With sequential choice much more restrictive assumptions are made in order to get existence and easy characterization of subgame-perfect equilibria (the assumptions are in any case usual in the literature). Section I presents the model, and our conclusions are given in Section IV.

I. The Model

We consider two firms $i=1,2$ selling a homogeneous product. Firm i is located at point y_i of the n-dimensional space $\mathbb{R}^n$ (when the model is interpreted in the geographical context, we have $n=2$) and produces the product at a constant marginal cost c_i. It is supposed that firms are not located at the same point, that is, $y_1 \neq y_2$. Consumers are continuously distributed over a compact subset X of $\mathbb{R}^n$. The density of demand for the product at $x \in X$ is given by a (measurable) function $f(p,x)$ of the full price p (that is, the price gross of transportation costs) paid by the consumers, and of the location x. The transportation cost of one unit of the product is given by a strictly increasing nonnegative function $t_i(\|y_i - x\|)$ of the distance $\|y_i - x\|$, where $\|\cdot\|$ is a norm defined on $\mathbb{R}^n$, with $t_i(0)=0$. In the geographical context typically, because of scale economies in transportation, t_i is a concave function of distance. Examples of norms that can be used are the Euclidean and the Manhattan norms.[7]

Two price policies are considered: uniform (U) and discriminatory (D). In the geographical context, uniform FOB pricing means that firm i charges the same mill price p_i to the consumers irrespective of their location. In this case, the full price of firm i at $x \in X$ is equal to the mill price plus the transportation cost, that is, $p_i(x) = p_i +$

[7]Other examples of norms used in location theory are the l_p-norms (see R. F. Love and J. G. Morris, 1979) and the block norms (see J. E. Ward and R. E. Wendell, 1985).

$t_i(\|y_i - x\|)$. This is so, for instance, because the transportation is under the control of the consumers who use the services of independent carriers charging $t_i(\cdot)$. In the rest of the paper, we refer to uniform FOB pricing as *uniform pricing*.[8] *Discriminatory pricing* occurs when firm i bears the transportation cost and chooses a price schedule $p_i(\cdot)$ which describes the delivered price $p_i(x)$ at which firm i is willing to supply consumers at location $x \in X$. The full price of firm i at x is now given by $p_i(x)$. The mill price effectively paid by the consumers, that is, $p_i(x) - t_i(\|y_i - x\|)$, generally changes with their location x. In other words, the firm discriminates among consumers on the basis of their location.

When the model is interpreted as a model of product differentiation, uniform pricing is equivalent to firm i's selling a *single* product located at y_i (in the characteristic space) and consumers paying a full price consisting of the price p_i of the product plus the cost $t_i(\|y_i - x\|)$ incurred by the consumers in using the services of independent producers who adapt firm i's product to their requirements given by x. Now t_i is better viewed as a convex function of distance. In the discriminatory case, firm i bears the cost $t_i(\|y_i - x\|)$ of redesigning its basic product (y_i) and offers the whole *band* of varieties. As product design is under its control, the firm may discriminate among consumers on the basis of their requirements. We say that price discrimination occurs when the price difference between two varieties does not correspond to the difference in the respective costs of redesigning the basic product.

A slightly modified version of the celebrated Hotelling model is a good example to illustrate the above general model. Let us first consider the geographical interpretation. Two sellers of a homogeneous product are located at the endpoints of Main Street; geometrically, $y_1 = 0$, $y_2 = 1$, and X is the segment $[0,1]$. They have identical and constant marginal production costs. Customers are uniformly distributed along Main Street and have fixed and identical requirements for the product. Finally, transportation costs are linear in distance. If both sellers follow a uniform price policy (as in Hotelling), consumers pay the price at the firm's door where a consumer buys the product plus the transportation cost for delivery. On the other hand, when sellers deliver the product (as the pizzaman), they may discern between consumers and price discriminate with respect to locations by absorbing part of the transportation costs.

Let us now come to the characteristics interpretation. Following Hotelling, we suppose that the segment $[0,1]$ describes the sweetness of cider: $y_1 = 0$ means sour cider and $y_2 = 1$ sweet cider. Under uniform pricing, firms produce only the two extreme products, and consumers adopt these products to their most preferred level of sweetness at a cost corresponding to the transportation cost in the geographical approach (how to change the sweetness of cider is a technical detail that we leave to the imagination of the reader). On the contrary, under discriminatory pricing, the firms offer the whole spectrum of sweetness and price each variety.

II. Simultaneous Choice of Policy and Price

In this section we investigate whether discriminatory or uniform pricing arises in equilibrium when firms choose simultaneously pricing policy and price, that is, when firms compete in price schedules which are unrestricted. A strategy for firm i is then a *price schedule* $p_i(\cdot)$ that specifies the delivered price at which firm i is willing to supply consumers at location x in X. The delivered price at x must cover the total (production plus transport) marginal cost. If firm i were to price *below* total marginal cost it could do at least as well, for any given price of the rival, by pricing *at* marginal cost. Formally, we assume $p_i(\cdot)$ to be in the set

$$\mathscr{P}_i \equiv \{\, p_i(\cdot) \text{ a nonnegative function defined on } X\text{, measurable and such that, for all } x \in X,\ p_i(x) \geq c_i + t_i(\|y_i - x\|)\,\}.$$

[8] Let us emphasize the fact that what we call here uniform pricing is different from uniform delivered pricing as defined in postage stamp systems.

The *potential market area* of firm i is the set of locations at which the firm faces a positive demand density when pricing at total marginal cost $m_i(x) \equiv c_i + t_i(\|y_i - x\|)$, that is,

$$A_i \equiv \{x \in X; f[m_i(x), x] > 0\}.$$

The most interesting case occurs when the set of consumers who consider buying from either firm, that is, $A_1 \cap A_2$, is nonnegligible (technically a nonzero measure set). Since the product is homogeneous, each consumer purchases from the firm with the lower delivered price. In the event of a price tie, we assume that consumers do the socially optimal thing and buy from the firm with the lower production and transportation cost. This may be rationalized noting that this firm can always price ε below its rival's total marginal cost. If, for some consumer location x, both firms have the same total marginal costs and charge the same delivered price, they split the local demand. Generically, the set of locations for which $m_i(x) = m_j(x)$ is negligible. To ease notation we will assume this to be the case.

Given the strategies $p_i(\cdot)$ and $p_j(\cdot)$ of the two firms, the *market area* of firm i, $M_i(p_i(\cdot), p_j(\cdot))$, is then the set of locations in the potential market area A_i for which, either firm i quotes the lower-delivered price or, if both firms quote the same price, firm i has the lower-total marginal cost. Firm i's *profits* are, therefore, equal to

$$\Pi_i(p_i(\cdot), p_j(\cdot)) = \int_{M_i(p_i(\cdot), p_j(\cdot))} [p_i(x) - m_i(x)] \times f[p_i(x), x]\, dx.$$

We thus have a well-defined game with strategy sets P_i and payoffs Π_i, $i = 1,2$. To analyze the Nash equilibria of this game, we need some additional assumptions and definitions.

Let us assume that, for each location x in X, the demand density $f(p, x)$ is continuous and downward sloping in p, and that $pf(p, x)$ is bounded from above. This implies that there exists a monopoly price for every x in X which, for simplicity, we assume unique. Denote by $p_i^M(x)$ the monopoly price of firm i at location x, that is,

$$p_i^M(x) = \arg\max_{p_i} \{(p_i - m_i(x)) f(p_i, x)\}.$$

We say that firm i has a *monopoly position* at location x whenever its monopoly price at x does not exceed the total marginal cost of the rival firm, that is, $p_i^M(x) \leq m_j(x)$, $i \neq j$.

Suppose now that firm i does *not* have a monopoly position at x. We say that firm i has a *cost advantage* at location x if its total marginal cost is lower than that of its rival, that is, $m_i(x) < m_j(x)$. Let x be such a location and define $\bar{p}_i(x)$ as the profit-maximizing price at x when firm i cannot charge more than $m_j(x)$, that is,

$$\bar{p}_i(x) \in \arg\max_{p_i} \{(p_i - m_i(x)) f(p_i, x); \; p_i \leq m_j(x)\}.$$

Without significant loss of generality, we may assume that $\bar{p}_i(x)$ is unique. Notice that when the profit $(p_i - m_i(x)) f(p_i, x)$ is quasi-concave in p_i, $\bar{p}_i(x)$ takes its highest possible value, namely $\bar{p}_i(x) = m_j(x)$. Otherwise, the profit is not single-peaked and there may be a local maximum at a price less than $m_j(x)$.

We claim that there exists an equilibrium for the above game in which firm i chooses a price schedule given by

$$p_i^*(x) = \begin{cases} p_i^M(x), & \text{if firm } i \text{ has a monopoly position at } x \\ \bar{p}_i(x), & \text{if firm } i \text{ does not have a monopoly position at } x \text{ but has a cost advantage} \\ m_j(x), & \text{otherwise.} \end{cases}$$

The argument is as follows. Since the marginal production cost of firm i is constant and since the transportation cost to a point is unaffected by transportation to other points, it is sufficient to show that, given $p_j^*(x)$, firm i maximizes its profit density at (almost) every x in X by setting $p_j^*(x)$. We have:

(i) If firm i enjoys a monopoly position at x, it will serve the local market and will reach its highest possible profits by monopoly pricing since $m_i(x) \leq p_i^M(x) \leq m_j(x)$.

(ii) If firm i does not have a monopoly position but has a cost advantage at x, then by pricing at $\bar{p}_i(x)$ it captures the local demand, since $\bar{p}_i(x) \leq m_j(x)$ and $m_i(x) < m_j(x)$, (recall that according to our convention if the two firms quote the same price consumers buy from the firm with lower total marginal cost) and maximizes its profits at x by definition of $\bar{p}_i(x)$.

(iii) If firm i has no cost advantage at x, that is, $m_i(x) \geq m_j(x)$, then for any price $p_i \geq m_i(x)$ the firm has no demand when $m_i(x) > m_j(x)$ since firm j can always undercut p_i, or it makes no profit when $m_i(x) = m_j(x)$. In any case, firm i earns zero profits and pricing at $m_i(x)$ is optimal.

Thus, as is often suggested in the marketing literature, $p_j^*(x)$ is set on the basis of either demand considerations, or, a combination of demand and competition considerations, or finally, purely cost considerations; the dominant consideration being determined by the consumer location x.

The above-described equilibrium is the only one of the game. Intuitively, this is easy to understand. Indeed, for a given location x in which no firm has a monopoly position, Bertrand competition drives prices down to the level of the larger total marginal cost, $\max\{m_1(x), m_2(x)\}$, which then allows the firm with the cost advantage, say firm i, to charge $\bar{p}_i(x)$. If firm i has a monopoly position then $p_i^M(x)$ necessarily obtains; and similarly for firm j.[9]

The *equilibrium market price schedule* is then

$$p^*(x) = \min\{p_1^*(x), p_2^*(x)\} \text{ for all } x \in X.$$

That is, $p^*(x)$ equals the minimum of the monopoly prices, $p_i^M(x)$, the constrained prices, $\bar{p}_i(x)$, and the maximum of the total marginal costs, $\max\{m_1(x), m_2(x)\}$.

The equilibrium is illustrated in the following example.

The set X is a linear segment of length 1; firms 1 and 2 are located respectively at $y_1 = 0$ and $y_2 = 1$; consumers have linear demand functions $1 - p$; production costs are zero and transportation costs are given by tx. For $1/2 \leq t \leq 2$, it is then easy to verify that

$$p_1^*(x) = p_1^M(x) = \frac{1}{2} + \frac{t}{2}x \quad \text{for } 0 \leq x \leq (2t-1)/3t,$$

$$p_1^*(x) = m_2(x) = t(1-x) \quad \text{for } (2t-1)/3t \leq x \leq \frac{1}{2},$$

and

$$p_1^*(x) = m_1(x) = tx \quad \text{for } \frac{1}{2} < x \leq 1.$$

A similar argument can be developed for $p_2^*(\cdot)$. Figure 1 represents the resulting market price schedule.

Interestingly, we notice that, over a certain range of locations ($(2t-1)/3t \leq x \leq \frac{1}{2}$ in Figure 1), the equilibrium price schedule is *decreasing* in the distance to the firm. The reason is that a firm faces fiercer competition in remote places—and thus sets lower delivered prices—than it does at home, for it has to compete with another firm which is closer to these points. This seems to be confirmed by the observations made by Greenhut (1981) for whom negatively sloped delivered price schedules frequently characterize oligopolistic firms in Japan and West Germany.[10]

[9]A more technical argument could be given following the lines of the proof of Theorem 1 in P. J. Lederer and A. P. Hurter (1986), (who consider the case of inelastic local demands).

[10]Greenhut reports that "this type of pricing...was never found...in the United States. Instead, the American firms always charged higher prices to more

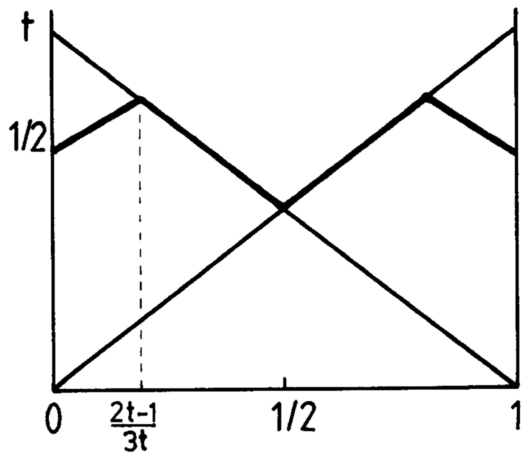

FIGURE 1. THE HEAVY LINE IS THE EQUILIBRIUM MARKET PRICE SCHEDULE

Proposition 1 states our result.

PROPOSITION 1: *Assume that the intersection of the potential market areas of the firms is a nonnegligible set. If there is competition in price schedules, then the unique Nash equilibrium market price schedule is*

$$p^*(x) = \min\{p_1^*(x), p_2^*(x)\}.$$

Obviously, equilibrium prices involve price discrimination. In other words, *uniform pricing is never an equilibrium* when the potential market areas have a nonnegligible intersection. If this intersection were to be negligible, then the two firms would become spatial monopolists. For one particular class of demand functions, negative exponential, discriminatory pricing boils down to uniform pricing.

distant buyers, or at the limit followed uniform delivered prices over their market space. Quite conceivably it is the Robinson-Patman Act that causes the delivered price patterns of American firms to differ from those of firms in West Germany and Japan" (see Greenhut, 1981, p. 84). This suggests that the corresponding institutional constraint is binding for many American firms. For an illustration, see the simulation made by B. F. Hobbs (1986a), of a deregulated bulk power market in the United States.

III. Commitment to a Price Policy

In this section we consider two-stage games in which firms may commit to a particular price policy, uniform pricing (U), or may not commit at all and stay free to choose an unrestricted price schedule (D) at the market competition stage (this involves price discrimination in general).[11]

In order to make the analysis tractable, we will restrict ourselves to simple cases in which consumers are uniformly distributed over some space X (a segment or a circle) and each one of them has an *inelastic* demand for one unit of the good. Attention will be focused on subgame-perfect equilibria of the two-stage games in which firms anticipate the resulting Nash equilibria in prices at the second stage when choosing its price policy at the first stage. If one firm chooses uniform pricing and the other discriminatory pricing, there may not be a simultaneous move Nash equilibrium (in pure strategies) at the second stage. In what follows, we will assume that the firm which chooses to price uniformly will move first and be the price leader while the other firm will react optimally to the leader's price. This situation fits the single-basing point pricing (BPP) system in spatial price competition and we will see that it has a natural interpretation in the context of product differentiation. We deal first with spatial price competition and the equilibrium analysis of the BPP system, and second with product differentiation and the pricing of varieties.

A. *Spatial Price Competition and Basing Point Pricing*

We suppose now that consumers are uniformly distributed with a unit density on the interval $X = [0,1]$, with firm 1 located at 0 and firm 2 at 1. Firms have constant marginal production costs and, without loss of generality, let them be 0 and $c \geq 0$ for firms 1 and 2, respectively. Transportation costs are linear with slope t ($t > 0$).

[11]A model similar in spirit is developed by N. Singh and X. Vives (1984).

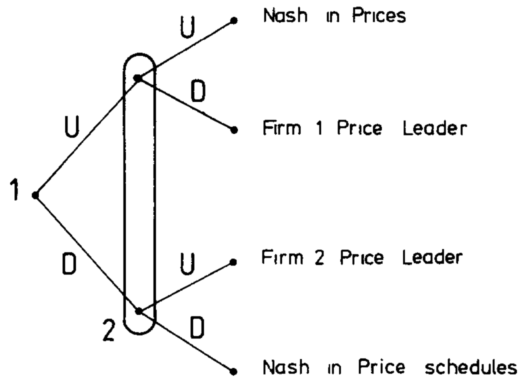

FIGURE 2. GAME TREE FOR THE SEQUENTIAL GAME WHERE FIRMS MAY EITHER COMMIT TO PRICE UNIFORMLY (U) OR KEEP THEIR FREEDOM OF PRICING (D)

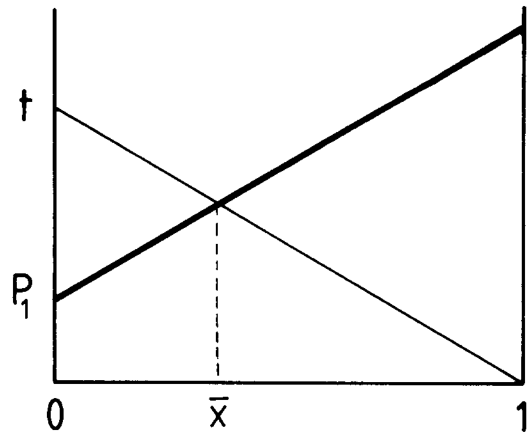

FIGURE 3. SINGLE-BASING POINT PRICING WITH BASE AT 0. THE HEAVY LINE IS THE FULL MARKET PRICE $p_1 + tx$. THE INTERSECTION WITH THE TOTAL MARGINAL COST OF FIRM 2 DETERMINES $\bar{x}$, THE MARKET SHARE OF THE LEADER

Firms may commit to uniform pricing first and then compete in prices accordingly. Four possible cases may arise: (U, U), (U, D), (D, U), or (D, D). If both firms choose to price uniformly, (U, U), then a Nash equilibrium in (FOB) prices obtains at the second stage. If both firms choose to keep complete freedom of pricing, (D, D), then a Nash equilibrium in price schedules obtains at the second stage. If firm 1 chooses to price uniformly and firm 2 does not commit, (U, D), then firm 1 will be a price leader and firm 2 will react optimally to its price (Figure 2 depicts the game tree).

This is a natural *competitive* view of the BPP system with a single-basing point (in which firm 1 is located at $y_1 = 0$). The leader announces a uniform base price, and the price the consumer pays is just the base price plus the transportation cost from 0 to the location of the consumer no matter what firm serves the consumer. Given the base price set by the leader, firm 2 then just undercuts the corresponding full price wherever possible. In other words, the market area of firm 2 is defined by the set of locations for which firm 1's full price is larger than the marginal production and transportation cost of firm 2. This is so because firm 1 is the first mover so that, for any posted price p_1, firm 2 can always capture the demand on $\{x \in X;\ P_1 + t|y_1 - x| > c + t|y_2 - x|\}$ by selling to consumers at $x\,\varepsilon$–below firm 1's full price (see Figure 3 where the market areas of firms 1 and 2 are given by $[0, \bar{x}]$ and $[\bar{x}, 1]$, respectively, when $c = 0$).[12] Firm 1 is, therefore, a price leader that sets a uniform FOB price and firm 2 reacts optimally to the leader's base price by price discriminating. The case (D, U) is similar. We have thus that the mixed cases (U, D) and (D, U) represent single BPP equilibria with base points 0 and 1, respectively. Our approach results in separated market areas and, therefore, no cross-hauling occurs, that is, there is no location where two-way trade is observed.[13]

We would like to examine the stability of basing point pricing in our competitive context. In particular, we would like to know whether BPP can emerge as an equilibrium of our two-stage game.

[12] Notice that the way demand is allocated between firms in the event of a price tie has been slightly modified with respect to the convention made in Section III where it was assumed that customers were assigned to the firm with the cost advantage.

[13] In practice, however, market areas are not so clearly delineated as in our competitive interpretation of BPP and cross-hauling may occur. This observation already suggests that the actual implementation of BPP may not be consistent with vigorous price competition since cross-hauling implies that firm 2 does not fully exploit its cost advantage with respect to the price set by firm 1.

In order to find the subgame-perfect equilibria of our game we compute the firms' payoffs in each of the four possible situations. The cases (U,U) and (D,D) are standard and we will review them very briefly. We will assume that $t>c$ to ensure that firm 2 (the high-cost firm) is not priced out of the market.

(U,U): The market boundary for the two firms is given by the location $\bar{x}$ of the consumer who is indifferent between buying from either firm: $p_1+t\bar{x}=p_2+t(1-\bar{x})$, from which it immediately follows that $\bar{x}=(p_2-p_1+t)/2t$. As consumers are distributed with a unit density, profits of firm 1 are given by $\pi_1=p_1\bar{x}$ and those of firm 2 by $\pi_2=(p_2-c)(1-\bar{x})$. The unique pair of equilibrium prices is obtained from the first-order conditions as

$$\left(t+\frac{c}{3},\,t+\frac{2c}{3}\right),$$

yielding market areas

$$\left(\frac{1}{2}+\frac{c}{6t},\,\frac{1}{2}-\frac{c}{6t}\right)$$

and equilibrium profits

$$\left(\frac{1}{2t}\left(t+\frac{c}{3}\right)^2,\,\frac{1}{2t}\left(t-\frac{c}{3}\right)^2\right).$$

(D,D): If both firms compete in price schedules, the equilibrium price schedule $p^*(x)$ is $\max\{tx,c+t(1-x)\}$, with $x\in[0,1]$, since localized Bertrand competition drives prices down to the higher total marginal cost (see Proposition 1). The market boundary is given by $x^*=1/2+c/2t$, while equilibrium profits are

$$\pi_1=\int_0^{x^*}[c+t(1-x)-tx]\,dx$$
$$=\frac{1}{4t}(c+t)^2 \quad \text{for firm 1, and}$$

$$\pi_2=\int_{x^*}^{1}[tx-(c+t(1-x))]\,dx$$
$$=\frac{1}{4t}(t-c)^2 \quad \text{for firm 2.}$$

(U,D): Here the efficient firm is the leader and prices uniformly at p_1. The market boundary $\bar{x}$ is determined by $p_1+t\bar{x}=c+t(1-\bar{x})$, which yields $\bar{x}=(t+c-p_1)/2t$, since the optimal response of firm 2 is to match firm 1's full price p_1+tx, whenever possible, that is when $p_1+tx\geq c+t(1-x)$. Profits of firm 1 are given by $\pi_1=p_1\bar{x}$ and the optimal price for firm 1 is $p_1^*=t+c/2$ with associated market boundary $x^*=t+c/4t$, yielding profits of $(t+c)^2/8t$. The equilibrium price schedule of firm 2 is $p_2^*(x)=\max\{p_1^*+tx,c+t(1-x)\}$ and the equilibrium profits are

$$\pi_2=\int_{x^*}^{1}\left[\frac{t+c}{2}+tx-(c+t(1-x))\right]dx$$
$$=\frac{(3t-c)^2}{16t}.$$

(D,U): We have now that the inefficient producer (firm 2) prices uniformly and is the price leader. A symmetric argument yields a market boundary $\bar{x}=p_2+t/2t$, an optimal price for firm 2 equal to $t+c/2$ with associated equilibrium profits $(t-c)^2/8t$. Equilibrium profits for firm 1 are $(3t+c)^2/16t$. Table 1 summarizes the payoffs for the firms.

It is clear from the table that to keep pricing freedom and to price discriminate is a dominant strategy for any firm no matter the difference in the production costs of the firms (provided that $c\leq t$). Commiting to uniform pricing is, therefore, a dominated choice. Proposition 2 states the result.

PROPOSITION 2: *In the sequential commitment game, choosing the price discrimination policy is a dominant strategy for any firm and, consequently,* (D,D) *with resulting market price schedule* $p^*(x)=\max\{tx,c+t(1-x)\}$ *is the unique subgame-perfect equilibrium.*

Proposition 2 says that no firm, not even the more efficient one, wants to be the price leader taking as basing point its location and, therefore, single BPP is not a stable configuration since it is not an equilibrium of our two-stage game. This suggests the

TABLE 1—SUMMARY OF FIRMS' PAYOFFS

1 \ 2	U	D
U	$\frac{1}{2t}\frac{(3t+c)^2}{9}, \frac{1}{2t}\frac{(3t-c)^2}{9}$	$\frac{1}{2t}\frac{(t+c)^2}{4}, \frac{1}{2t}\frac{(3t-c)^2}{8}$
D	$\frac{1}{2t}\frac{(3t+c)^2}{8}, \frac{1}{2t}\frac{(t-c)^2}{4}$	$\frac{1}{2t}\frac{(t+c)^2}{2}, \frac{1}{2t}\frac{(t-c)^2}{2}$

hypothesis that BPP cannot be explained in the context of a noncooperative model in which firms can choose their price policy and in which there is no repeated competition. Our analysis thus contrasts with the view (see, for example, D. H. Haddock, 1982) that BPP is fundamentally "competitive" and suggests that theoretical explanations of BPP should consider its role as a coordinating and collusive device (see Scherer, 1980, and G. Stigler, 1949). Nevertheless, our hypothesis will obviously not hold when BPP coincides with the discriminatory solution. This would be the case, for example, when firm 1 has a second plant established next to firm 2 at location $y_2=1$ and both firms are equally efficient. Indeed, in the region where no firm has a cost advantage, competition would drive prices down to total marginal cost, while in the region in which firm 1 has a cost advantage, the delivered price will be equal to the total marginal cost of firm 2, that is, the equilibrium market price schedule would be given by $t(1-x)$ for $0 \leq x \leq 1$. It is then clear that the above solution corresponds to BPP with a single-basing point at $y_2=1$.

In the symmetric case where firms are of equal productive efficiency, $c=0$, we have a typical Prisoner's Dilemma situation since to price discriminate is a dominant strategy but firms would make more profits by pricing uniformly.[14] In the (U,U)-case each firm earns $t/2$, whereas in the (D,D)-case each firm earns $t/4$. Consumer surplus is larger in this latter case since the full price at x is given by $p^D(x)=\max\{tx, t(1-x)\}$, whereas in the (U,U)-case the uniform price is t and, therefore, the full price at x is given by $p^U(x)=\min\{t+tx, t+t(1-x)\}$, which is strictly larger than $p^D(x)$ for $0<x<1$: each consumer in $]0,1[$ is, therefore, better off under discriminatory than uniform pricing while consumers located at $x=0$ and $x=1$ are indifferent (see Figure 4). Note nevertheless that total surplus is equal in both cases; the pricing policy only affects the distribution of surplus between firms and consumers. To check our claim suppose that consumers have a (high enough) reservation price v ($v \geq 3t/2$) and that the utility provided by the consumption of one unit of the good equals v minus the full price paid by the consumer. We have then that total surplus in the market is $v-t/2$ in both cases, the differences between the reservation price and the transportation cost of the consumer located in the middle of the segment.

Imagining that location 0 corresponds to Pittsburgh and location 1 to Chicago, the case (U,D) would represent the Pittsburgh-plus system implemented until the mid-1920s in the U.S. steel industry. After that period, several basing points were introduced involving, among others, both Pittsburgh and Chicago. Superficially, the (U,U)-case could then be viewed as a very simplified version of the multiple-basing point system with two basing points at locations 0 and 1. Actually, this turns out not to be true as this system is always associated with the so-called "alignment rule" (see Phlips, 1983, ch. 1, and Scherer, 1980, ch. 11). According to this rule, a firm will always accept to sell at the lower

[14] This result holds in various models: linear demand and endogenous location (A. Kats, 1987) and product differentiation modeled by the logit (S. P. Anderson et al., 1987). Notice, however, that discriminatory pricing may yield higher profits than uniform pricing when firms have monopoly positions in some large enough segments of the market.

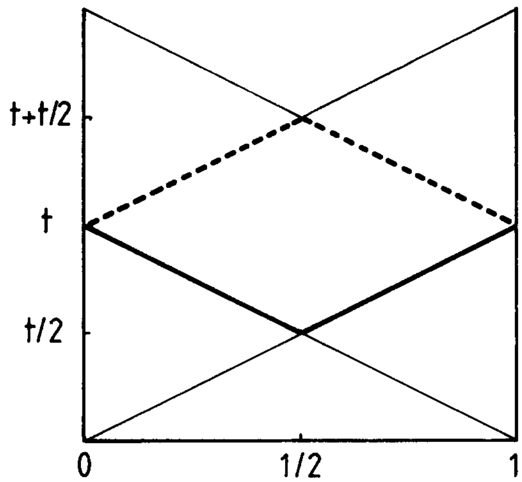

FIGURE 4. THE HEAVY LINE IS THE MARKET EQUILIBRIUM PRICE SCHEDULE WITH DISCRIMINATORY PRICING, $p^D(x) = \max\{tx, t(1-x)\}$. THE DOTTED LINE CORRESPONDS TO THE UNIFORM PRICING CASE, $p^U(x) = \min\{t(1+x), t(2-x)\}$.

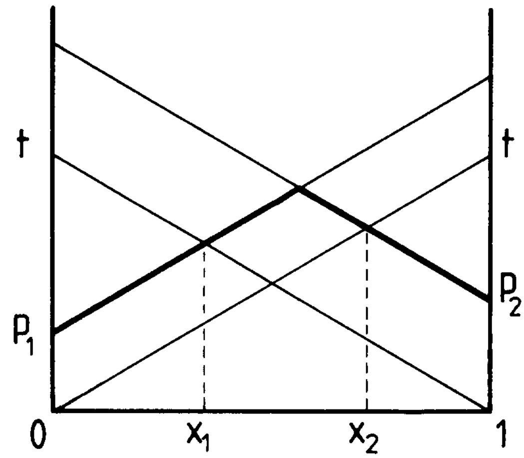

FIGURE 5. MULTIPLE-BASING POINT PRICING WITH BASES AT 0 AND 1. THE HEAVY LINE REPRESENTS THE DELIVERED PRICES FACED BY CONSUMERS

full price so that firms quote the same delivered price to everyone at each location (provided that this price is large enough for the firm to cover its marginal cost). Let us assume, for simplicity, that $c = 0$ so that both firms are equally efficient. Then, if firms 1 and 2 charge base prices p_1 and p_2, we can see in Figure 5 that customers located in $[x_1, x_2]$ may pass orders to either firm since, by assumption, they both set the same delivered price at $x \in [x_1, x_2]$. As any assignment rule is a priori arbitrary at this stage of the analysis, we may follow A. Smithies (1942) and suppose that firms equally share the local market in the interval $[x_1, x_2]$. In this case, it is readily verified that, at the Nash equilibrium in base prices, both firms charge a base price that is just equal to the common equilibrium price arising in the (U, U)-case, that is, $p_1^* = p_2^* = t$. However, because of the existence of cross-hauling over $[x_1, x_2]$, the corresponding equilibrium profits are lower and given by $\frac{3}{8}t$. It is interesting to observe that these profits are still larger than those earned at the noncooperative equilibrium of our two-stage game (D, D), *but* lower than those obtained at the "cooperative" solution (U, U). What Smithies' approach leaves unexplained is the market sharing in the interval $[x_1, x_2]$ since, according to our results, firms have a strong incentive to price discriminate. Market sharing in the common area $[x_1, x_2]$ gives the multiple BPP a noncompetitive flavor.[15]

B. *Product Differentiation and the Pricing of Varieties*

Consider consumers distributed uniformly over the unit circle with firms 1 and 2 in arbitrary locations, the shortest arc distance between them being s (that is, $s \leq 1/2$). In Figure 6, firm 1 is located at $x = 0$ and firm 2 at $x = s$. Suppose that firms have no production costs and that transportation costs are quadratic with coefficient t and no linear term. (As explained in Section I, here transportation costs will be the costs associated with transforming a base product into a variety or specialized product.)

[15] However, Smithies is probably right when he claims that this system is far from complete agreement since profits are lower than in the second-best (U,U)-case.

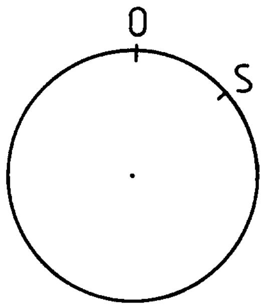

FIGURE 6. FIRM 1 IS LOCATED AT $x = 0$, FIRM 2 AT $x = s$

In the situation we have in mind each firm produces a base product, corresponding to its location in product space (the circle), and at the first stage it has to decide whether to (potentially) offer the whole array of varieties and price discriminate or just to offer the base product and price uniformly therefore. In the latter case the supply of specialized varieties is left to outside independent producers which, we will assume, price competitively at cost. In any case, we assume that the costs of redesigning the base product increase quadratically with the distance at which the variety chosen is located. The first-stage choice could also be interpreted as a decision as whether to integrate forward or not. The base product could be a base chemical or steel and the varieties the specialized chemicals or steels. Whatever the interpretation, if a firm chooses to produce only the base product, then it will choose a uniform price, and if it chooses to offer the array of varieties, it will choose a price schedule when the market stage comes. As before we assume that in the mixed cases (U, D) or (D, U) the firm that prices uniformly moves first and therefore Figure 2 represents the game tree of our game. This may come about because this firm may need to advertise its price in order to get any sales (put advertisements in the newspapers, for example), whereas the price-discriminating firm may just announce that it will meet the competition (in any case to announce the whole price schedule in an intelligible way may be too complex and costly due to the large number of varieties).

TABLE 2—FIRM 1'S PROFITS

1 \ 2	U	D
U	$\frac{1}{2}s(1-s)t$	$\frac{1}{8}s(1-s)t$
D	$\frac{9}{16}s(1-s)t$	$\frac{1}{4}s(1-s)t$

It is a simple exercise to find the second-stage equilibria for the different cases. Note that since transportation costs are quadratic (with no linear term) an equilibrium in prices will always exist in the (U, U)-case whatever the locations of the firms. In the Appendix we provide the computations that lead to the profits of firm 1 in the four cases given in Table 2 (profits of firm 2 have similar expressions).

As before, to choose the price-discriminating strategy is dominant for any firm in the circle model with quadratic costs. No firm wants to produce only the base product whatever the rival firm strategy is. It always pays to offer the whole array of varieties and let the market decide which ones will be effectively produced by each firm. As in the previous models, price discrimination gives more flexibility to a firm to respond to any potential strategy of the rival. A product proliferation strategy (in terms of horizontal differentiation) can thus be seen as an attempt by a firm to secure a flexible position for the ensuing price competition.

In fact we have checked that the same is true in a unit-segment model with quadratic transportation costs if the firms are symmetrically located. The payoffs to firm 1 are given by Table 2's dropping the common terms $s(1-s)t$. If firms are asymmetrically located in the segment, then (D, D) is still the unique subgame-perfect equilibrium of the two-stage game but it is no longer necessarily a dominant strategy equilibrium. Going back to Table 2, we observe that, as in the location model considered in Section III, Part A, the firms face a Prisoner's Dilemma-type situation with higher profits in the (U, U)-case whereas the equilibrium dictates (D, D). Total surplus is equal in both situations and therefore, consumer surplus is higher with price discrimination and the two firms (potentially) offering the whole array of varieties.

IV. Concluding Remarks

We have examined the implications of letting firms choose their price policy in the context of a spatial competition model with given locations for firms. Either firms choose simultaneously price policy and actual prices, or firms may commit to a certain policy (uniform pricing) before the actual price competition takes place. The general conclusion is that *there is a robust tendency for a firm to choose the discriminatory policy* since it is more flexible and does better against any generic strategy of the rival, although, as we have seen in the models of Section III, firms may end up worse off than if they choose to price uniformly.

Furthermore, in those models, prices that consumers paid under uniform pricing were higher than under discriminatory pricing. This is not totally surprising: denying a firm the right to meet the price of a competitor on a discriminatory basis provides the latter with some protection against price attacks. The effect is then to weaken competition, contrary to the belief of the proponents of naive application of legislation prohibiting price discrimination like the Robinson-Patman Act in the United States, or similar recommendations of the Price Commission in the United Kingdom. Actually, as observed by E. M. Hoover,

> The difference between market competition under FOB pricing (with strictly delineated market areas) and under discriminatory delivered pricing is something like the difference between trench warfare and guerilla warfare. In the former case all the fighting takes place along a definite battle line; in the second case the opposing forces are intermingled over a broad area.
> [1948, p. 57]

Our results are short-run results since both the location and the number of firms are given. We know that the choice of a particular price policy leads to different long-run equilibrium patterns (see, for example, Greenhut et al., 1987, Part III). When policy and prices are chosen simultaneously, Proposition 1 (that can be generalized to the case of any number of firms) indicates that, at the long-run equilibrium, firms will choose to price discriminate in the absence of institutional constraints. Thus, at the long-run equilibrium, uniform pricing would not be observed. P. J. Lederer and A. P. Hurter (1986) have shown that, with perfectly inelastic demand, two price-discriminating firms will locate in order to minimize total transportation costs. In a free-entry context, the configuration of firms minimizing total production and transportation costs corresponds to a long-run equilibrium (see W. B. MacLeod et al., 1985). Furthermore, in a free-entry, zero-profit equilibrium with linear demand, B. F. Hobbs (1986b) shows that welfare under discriminatory pricing is higher than under mill pricing for a wide range of fixed cost values.[16] These results, together with ours, point to the social desirability of price discrimination in spatial competitive markets. However, more work is called for before having robust policy-oriented recommendations.

Our analysis has also helped to clarify some issues related to standard business practices. With respect to geographical pricing policies, the tendency toward price discrimination makes in general the basing point system unstable since no firm, not even a very efficient one, would like to commit to uniform (FOB) pricing. Therefore, if the system is observed in practice, most probably it is because it serves as a coordinating or collusive device in a situation of repeated competition. With respect to pricing in a product-differentiation context, the link between pricing policies and product strategies has been highlighted, noticing that for a firm to be able to price discriminate it must offer a band of varieties. Since it always pays to price discriminate, this may explain in part the observed change of firms' strategies from

[16] Like most models of spatial monopolistic competition, Hobbs assumes that firms are equally spaced. However, no justification is provided for that property

producing a single-standarized product to offering a whole spectrum of options.

Much work needs to be done to gain a solid understanding of current business pricing policies. Ours is only a first attempt and an illustration of how simple game-theoretic techniques may help to illuminate the issues involved.[17]

APPENDIX

Assume that locations (x) along the circle of unit length are measured in a trigonometric manner. Firm 1 is at $x = 0$ and firm 2 at $x = s$ with $0 < s \leq 1/2$.

(U, U): Consumers are indifferent between purchasing from either firm at points $\bar{x} = (p_2 - p_1 + ts^2)/2ts$ and $\bar{y} = p_1 - p_2 + t(1-s^2)/2t(1-s)$. Consequently, profits of firm 1 are $\pi_1 = p_1(1 - \bar{y} + \bar{x})$ and profits of firm 2 are $\pi_2 = p_2(\bar{y} - \bar{x})$.The unique price equilibrium is given by $(ts(1-s), ts(1-s))$, yielding equilibrium profits $(ts(1-s)/2, ts(1-s)/2)$.

(D, D): If both firms price discriminate, it is readily verified that the equilibrium price schedule is given by

$$\text{(A1)}\quad p^*(x) = \begin{cases} \max\{tx^2, t(x-s)^2\} & \text{for } 0 \leq x \leq 1/2 \\ \max\{t(1-x)^2, t(x-s)^2\} & \text{for } 1/2 \leq x \leq 1/2 + s \\ \max\{t(1-x)^2, t(1-x+s)^2\} & \text{for } 1/2 + s \leq x \leq 1. \end{cases}$$

The market boundaries are given by $\bar{x} = s/2$ and $\bar{y} = 1/2 + s + s/2$, whereas the equilibrium profits are

$$\text{(A2)}\quad \pi_1 = \int_0^{s/2} [p^*(x) - tx^2]\, dx + \int_{1/2+s}^{1} [p^*(x) - t(1-x)^2]\, dx = \frac{ts(1-s)}{4};$$

similarly,

$$\text{(A3)}\quad \pi_2 = \frac{ts(1-s)}{4}.$$

(U, D): Firm 1 is the leader and prices uniformly at p_1. Given p_1, firm 2 sets a price at x which is equal to the maximum of firm 1's full price at x and firm 2's transportation cost to x. Accordingly, the market boundaries are as follows: (i) for $p_1 \leq ts^2$, we have $\bar{x} = (-p_1 + ts^2)/2ts$ and $\bar{y} = p_1 + t(1-s)^2/2t(1-s)$; (ii) for $ts^2 < p_1 \leq ts(1-s)$, we have $\bar{\bar{x}} = -p_1 + ts^2 + 2ts)/2ts$ and $\bar{\bar{y}} = \bar{y}$ (when $p_1 > ts(1-s)$ and all consumers buy from firm 2). Firm 1's profits are respectively defined by $\pi_1 = p_1(1 - \bar{y} + \bar{x})$ and $\pi_1 = p_1(\bar{\bar{x}} - \bar{y})$. *A x* $\bar{\bar{x}} = \bar{x} + 1$, the expression of the profit function is uniquely determined and the profit-maximizing price of firm 1 is $p_1^* = ts(1-s)/2$. The corresponding demand is $1/4$ and the equilibrium profits of firm 1 are $ts(1-s)/8$. For firm 2, the equilibrium price schedule is given by

$$\text{(A4)}\quad p_2^*(x) = \begin{cases} \max\{p_1^* + tx^2, t(x-s)^2\}, & \text{for } 0 \leq x \leq 1/2 \\ \max\{p_1^* + t(1-x)^2, t(x-s)^2\}, & \text{for } 1/2 \leq x \leq 1/2 + s \\ \max\{p_1^* + t(1-x)^2, t(1-x+s)^2\}, & \text{for } 1/2 + s \leq x \leq 1 \end{cases}$$

and the equilibrium profits are

$$\text{(A5)}\quad \pi_2 = \int_0^{\bar{x}} [p_2^*(x) - tx^2]\, dx + \int_{\bar{y}}^{1} [p_2^*(x) - t(1-x)^2]\, dx$$

[17]Many other relevant issues have been left out. For example, we have considered complete information models (for models with informed and uninformed buyers, see, for example, S. Salop and J. Stiglitz, 1977, and M. L. Katz, 1984) and we have ignored the possibility of nonlinear pricing (see D. Spulber, 1981, for a study of nonlinear pricing in a spatial context).

or

$$\pi_2 = \int_{\bar{\bar{Y}}}^{\bar{\bar{x}}} \left[p_2^*(x) - t(1-x)^2 \right] dx,$$

which are both equal to

$$\tfrac{9}{16} ts(1-s).$$

(D, U): This is perfectly similar to the above one (up to a rotation of $1-s$ and a permutation of firms' names). Equilibrium profits are therefore

$$\pi_1 = \frac{9}{16} ts(1-s) \quad \text{and} \quad \pi_2 = \frac{ts(1-s)}{8}.$$

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