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PRODUCT IMITATION, PRODUCT DIFFERENTIATION AND INTERNATIONAL TRADE*

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Using the Hotelling approach to product differentiation, this article derives the equilibrium product configurations and prices when two firms enter and sell in two interdependent markets separated by barriers to trade. It shows that product imitation and no trade as well as product differentiation with two-way or one-way trade are all consistent with the equilibrium.

1. INTRODUCTION

In British Columbia, several microbrewers explicitly indicate on their products that they are "brewed according to the Bavarian purity laws of 1516," imitating thereby a product attribute of German beers. In contrast, firms in the watch industry often go out of their way to differentiate their products (for instance the Swatch). Beers brewers could have chosen differentiation and develop a specific taste or process. My model suggests that the choice between imitation and differentiation is determined by the existence of transport costs and tariffs. They increase the price of German beers in British Columbia and, thus, affect the location decision of domestic firms. Indeed, the Canadian duty on European beers is high since it is approximately 30 percent of the retail price of domestic products (Globe and Mail 1993). In the watch industry, protection and transport costs are too low with respect to the unit value of the product for legal imitation to be profitable.

This paper investigates the choice of product attribute in a model of horizontal differentiation with international trade. It shows that product imitation is a natural outcome of trade protection and international transport cost. However, the model goes beyond these examples. My aim is to derive the *international product configuration* and not simply the location choice of a new firm as in the microbrewer example. In this model, product imitation does not arise from shopping costs faced by consumers when they switch products as in Klemperer (1992). Thus, product imitation due to barriers to trade is complementary to the shopping cost argument.

Contrary to the effects of protection on quality (Falvey 1979, Krishna 1990), the relationship between horizontal differentiation and protection is not well developed.

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No attempt has been made to derive jointly the pattern of trade and the international market structure. That is, to determine not only the equilibrium price and quantity, but also the number of firms, their market of production and the attribute of each product. The approach usually adopted in the intra-industry trade literature does not allow for the determination of all these variables (see Helpman and Krugman 1985 or Greenaway and Milner 1986 for surveys). In particular, most models use a nonaddress approach to product differentiation, where goods are characterized by the volume of production and price, and not by their attributes (for instance Dixit and Stiglitz 1977 approach to product differentiation). In these models, the zero-profit equilibrium can be derived, but nothing can be said about product choice and strategic interactions between firms.

Some papers use an address model of product differentiation, either with the Lancaster's characteristics approach (Lancaster 1980, Helpman 1981), or with the Hotelling's spatial approach (Schmitt 1990, 1993). In these models, the product attribute is a choice variable but endogenous market structures and patterns of trade are disregarded. Firms are often assumed to relocate freely in the product space, which results in a symmetric equilibrium with an indeterminate direction of trade (Helpman 1981, Lancaster 1980, Schmitt 1990). Alternatively, symmetric product locations are sometimes imposed at the outset (Lancaster 1984, Schmitt 1993).

Moreover, all these models assume that there are many firms. There is no reason to believe that the market equilibrium with intra-industry trade could not also result from competition among a few firms earning pure profits. However if this is the case, interactions between firms must be considered. Thus, a model describing such an equilibrium must have one fundamental property: product attribute, or firm's location, must be an explicit choice variable. To do so, I extend Hotelling (1929)'s spatial model to an international trade environment with two markets. Each market is represented by the unit line which provides the continuum of potential product attributes along which consumers' preferences are distributed. Each firm produces a single good with a specific attribute, which is then sold in one or both markets. The model investigates where firms establish production and which attribute they choose knowing that product attributes are fixed once chosen. In particular, I show when firms will imitate each other's product and when they will differentiate them.[2]

In this paper, I investigate and contrast two games: one in which firms choose product attributes simultaneously, and the other in which firms choose them sequentially. Games of sequential entry with fixed locations follow from contributions in industrial organization where firm's locations and market structure are derived in a closed economy (Hay 1976, Prescott and Visscher 1977, Lane 1980, Eaton and Kiezkowski 1984a, Neven 1987). Of course, sequential entry is only one possible way to analyze these issues. This implies that there is enough time between entry attempts during which each potential firm can precisely observe which locations (or product attributes) have been selected. In addition, market structure is not

[2] This paper endogenizes the choice of product attribute and the market of production when firms can trade only. In contrast, Horstmann and Markusen (1992) endogenize the firm's organization of production in a world supporting two firms producing a homogeneous good.

fully endogenized as the sequence of entry is not explained. Nevertheless, sequential entry adds some structure to the game which often eliminates ranges of parameters where there is no equilibrium in pure strategies. It also allows for strategic interactions between firms since it introduces an asymmetry between existing and potential firms. By extending this model of sequential entry to a multi-market environment, patterns of trade become by-products of the equilibrium market configurations.

With a maximum number of firms (or products) restricted to two, this paper shows that, depending on the parameters of the model, three product configurations and patterns of trade emerge in equilibrium: product imitation where each firm is a monopoly in its own market, duopoly with product differentiation and two-way trade, and duopoly with product differentiation and one-way trade. All these equilibria are obtained from a very small set of equilibrium product attributes.[3] Furthermore, it is shown that, as compared to the equilibrium with simultaneous choice of product attributes, sequential entry increases the scope for product imitation, increases the scope for two-way trade, and decreases the scope for one-way trade.

The paper is organized as follows: the model is outlined in Section 2 and the determination of the prices is analyzed in Sections 3. In Section 4, the firms' choice of product attribute is investigated in detail and some concluding comments are offered in Section 5.

2. THE MODEL

The analysis is casted in an address model in the Hotelling tradition. In such models, each good is described by a point x in some continuum of product attributes; I work here with a one-dimensional attribute space.[4] I begin the analysis by a description of the main features of the model.

2.1. *Markets and Preferences*. A market in this model can be interpreted as a country or as a region. Specifically, it is defined as a one-dimensional attribute space with support $[0, 1]$ representing both the consumers' set of preferences and the firms' feasible attribute space for products. Two interdependent markets are considered. Thus, goods produced in one market can be shipped and sold in the other subject to an exogenous specific barrier to trade t. The parameter t represents either a tax on trade (tariff or export tax) or the transport cost between the two markets. It is assumed throughout that t is a tariff rate and that it is independent of the direction of trade.[5]

[3] Eaton and Kierzkowski (1984b) also investigate the firms' product choice in a two-market environment. They restrict however the consumers' preferences to two possible product attributes and do not explicitly consider barriers to trade.

[4] The unit-line is chosen for convenience and tractability. Although unique equilibrium locations would not exist with circles for instance, the incentive to imitate and to differentiate product attributes would still remain.

[5] This assumption is relaxed in Schmitt (1991).

Markets are identified by index j ($j = A, B$) and products by index i. For a consumer located in market j, any good is completely described by its address x_i in the attribute space and by its mill price s_{ij}. By assumption, any consumer buys exactly one unit of only one of the goods, or else none at all. The utility from buying one unit of good x_i at price s_{ij} is

$$(1) \qquad V(x_i, s_{ij}) = v - a(x_i - x^*)^2 - s_{ij},$$

where x^* in $[0,1]$ describes the consumer's most preferred good, and v is the consumer's reservation price for that good. Given a choice among several products, the consumer buys one unit of the good for which $V(x_i, s_{ij})$ is a maximum provided that the maximum is positive. The consumer buys none of these goods if the maximum is negative. Since $|x_i - x^*|$ represents the distance from x_i to the consumer's most preferred attribute, $a(x_i - x^*)^2$ is the disutility associated with consuming a different product than x^*. This term is quadratic to ensure the existence of an equilibrium (d'Aspremont et al. 1979). The parameters v and a are positive and identical for all consumers in both markets. The parameter x^*, however, varies among consumers and is uniformly distributed along the unit interval with density D_j. Without loss of generality, it is assumed that density in market A is at least as high as in market B ($D_A \geq D_B$). Tax revenues in market j are redistributed to consumers of j. Note, however, that this redistribution has no effect on the demand for good i since individual demands are price inelastic. Import and export taxes lead therefore to the same conclusions.

Finally, let's define

$$v_i = v - a \max\left[x_i^2; (1 - x_i)^2\right], \qquad i = 1, 2,$$

as the reservation price of the individual whose x^* is most distant from x_i. Markets are assumed to be covered implying that $s_{ij} \leq v_i$.

2.2. *Firms and Structure of the Game*. Each firm produces a single good and each firm's production takes place in one market only. Thus, the model is one of inter-market (or international) trade and not one of multi-market firm production.[6] There is no cost of production and it is assumed that product attributes are fixed once chosen.[7] Any firm producing good x_i in one market can also export and sell the *identical* product to the other market. Thus, product x_i can be both a *domestic* product when it is sold in the same market as it is produced, and a *foreign* product when its market of consumption does not coincide with its market of production.

It is assumed that *within each market*, firms adopt a single mill price for all their customers. *Across markets* however, firms use price discrimination. Thus, they

[6] See Schmitt (1993) for a spatial analysis involving multinationals.

[7] The presence of sunk costs usually justifies this assumption. I disregard them or equivalently I assume that they are sufficiently low so that the two firms always enter.

perceive the two markets as separate entities for which distinct mill price decisions can be made. The first assumption is identical to the one used by Prescott and Visscher, Lane and others, and the second one is known in the international trade literature as the market segmentation hypothesis (see Markusen and Venables 1988 for a discussion). The domain of analysis is restricted to two firms at most. Then, in any given market, consumers face at least one product, but no more than two of them.

Given these assumptions, the market demand for product i in market j is derived in the standard fashion by finding the most preferred attribute of the consumer who is just indifferent between good x_1, sold at mill price s_{1j} and good x_2, sold at s_{2j}. This critical point, denoted x^j, is found by equating $V(x_1, s_{1j}) = V(x_2, s_{2j})$ for $j = A, B$. Given (1),

$$x^j = \frac{s_{2j} - s_{1j}}{2a(x_2 - x_1)} + \frac{x_2 + x_1}{2}, \tag{2}$$

for $x_1 \leq x_2$. The demand for product i $(i = 1, 2)$ in market j is thus

$$Q_{1j}(s_{1j}, s_{2j}, x_1, x_2) = D_j x^j, \tag{3.1}$$

$$Q_{2j}(s_{1j}, s_{2j}, x_1, x_2) = D_j(1 - x^j), \tag{3.2}$$

for $0 \leq x^j \leq 1$. Notice that when $x^j = 0$ $(x^j = 1)$, firm 2 (firm 1) is the only seller in market j, whereas products 1 and 2 share market j whenever $0 < x^j < 1$.

Two games are analyzed. First, I investigate the two-stage game in which both firms choose simultaneously their product attribute and, in the second stage, they choose their prices simultaneously. Firm 1 is assumed to select its product attribute $x_1 \in [0,1]$ in market A (this assumption is further discussed in Section 4), whereas firm 2 chooses $x_2 \in [0,1]$ in market A or B. Without loss of generality, it is assumed that $x_2 \geq x_1$. The second game is a three-stage game of sequential entry. In the first stage, firm 1 (the first mover) selects a product characteristic $x_1 \in [0,1]$ in market A. In the second stage of the game, firm 2 chooses whether to enter or not. If it does enter, it selects market of production A or B and its product attribute $x_2 \in [0,1]$ such that $x_2 \geq x_1$. In the third stage of the game, both firms announce prices simultaneously. Hence, when the last stage of the game is reached, both firms know the product attributes and each other's market of production. The price equilibrium is a set of prices maximizing the profit of each firm given the price chosen by its rival (Nash equilibrium). This procedure defines a perfect equilibrium in the three-stage game (Selten 1975) with well-known properties (see Fudenberg and Tirole 1992). Since backward induction is needed to solve both games, I first investigate the pricing decisions by the firms.[8]

[8] Since this is a game of perfect information, firms know the tariff rate they would face in case of entry. This is not unrealistic as firms can readily know to which tariff classification a new product would belong.

3. PRICING STAGE

Each firm i selects a single price for each market. Specifically, firm i selects producer price r_{ij} for product x_i and, thus, maximizes, with respect to r_{ij},

$$\pi_i = \sum_j \left[r_{ij} Q_{ij}(s_{1j}, s_{2j}, x_1, x_2) \right], \qquad i = 1,2; \quad j = A, B, \tag{4}$$

where s_{ij} is the consumer's mill price of product x_i. The relationship between s_{ij} and r_{ij} depends on whether product i is a domestic or a foreign product in market j. Since good 1 is produced in market A, then $s_{1A} = r_{1A}$ and $s_{1B} = r_{1B} + t$. For product 2, we define d_2 where $d_2 = 0$ when good 2 is produced in market A and $d_2 = 1$ when it is produced in B; thus, $s_{2A} = r_{2A} + d_2 t$ and $s_{2B} = r_{2B} + (1 - d_2)t$.

Consider now market A. Given (2) and (3.1), the demand for product 1 in $A, Q_{1A}(r_{1A}, r_{2A}, x_1, x_2, d_2)$, is

$$
\begin{aligned}
Q_{1A}(r_{1A}, r_{2A}, x_1, x_2, d_2) &= 0 && \text{if } r_{1A} \geq r'_{1A}, \\
&= \frac{D_A}{2a(x_2 - x_1)} \left[r_{2A} + d_2 t - r_{1A} + a\left(x_2^2 - x_1^2\right) \right] && \\
& && \text{if } r''_{1A} < r_{1A} < r'_{1A}, \\
&= D_A && \text{if } r_{1A} \leq \min\{r''_{1A}; v_1\},
\end{aligned}
$$

where $r'_{1A} = r_{2A} + d_2 t + a(x_2^2 - x_1^2)$ and $r''_{1A} = r_{2A} + d_2 t + a(x_2^2 - x_1^2) - 2a(x_2 - x_1)$. Likewise, given (2) and (3.2), the demand for product 2 in $A, Q_{2A}(r_{1A}, r_{2A}, x_1, x_2, d_2, t)$, is

$$
\begin{aligned}
Q_{2A}(r_{1A}, r_{2A}, x_1, x_2, d_2) &= 0 && \text{if } r_{2A} \geq r'_{2A}, \\
&= \frac{D_A}{2a(x_2 - x_1)} \left[r_{1A} - r_{2A} - d_2 t + 2a(x_2 - x_1) - a\left(x_2^2 - x_1^2\right) \right] && \\
& && \text{if } r''_{2A} < r_{2A} < r'_{2A}, \\
&= D_A && \text{if } r_{2A} \leq \min\{r''_{2A}; v_2 - d_2 t\},
\end{aligned}
$$

where $r'_{2A} = r_{1A} - d_2 t + 2a(x_2 - x_1) - a(x_2^2 - x_1^2)$ and $r''_{2A} = r_{1A} - d_2 t - a(x_2^2 - x_1^2)$. The demand function for any good in any market has three regions: zero demand for product i as r_{ij} is above the critical price r'_{ij}; positive and linearly increasing demand for i as r_{ij} falls; and totally inelastic demand at D_j when r_{ij} is low enough to attract all the consumers in j. In the last region, the price must be consistent with the reservation price of the most distant consumer in that market. Since the demand functions are quasi-concave, since the markets are segmented and since there are no variable costs of production, a price equilibrium must exist in each market. Furthermore, each price can be derived independently.

To find the price equilibrium in market A, consider first firm 1's best reply functions. When both firms share A (i.e., $0 < x^A < 1$), it is

$$r_{1A} = \frac{1}{2}\left[r_{2A} + d_2 t + a\left(x_2^2 - x_1^2\right)\right], \tag{5.1}$$

and when firm 1 is the only seller in A ($x^A = 1$), its best reply is

$$r_{1A} = \min\left\{r_{2A} + d_2 t + a\left(x_2^2 - x_1^2\right) - 2a(x_2 - x_1);\, v_1\right\}. \tag{5.2}$$

The first expression on the right-hand side of (5.2) is firm 1's limit price; namely, the price which makes the demand for product 2 in market A just equal to zero. The second price in (5.2) is firm 1's monopoly price. In effect, by adopting v_1, firm 1 can disregard firm 2's threat to sell in market A and still be the only seller in that market while covering it. Since markets are always covered, v_1 is never adopted unless it also pays firm 1 to adopt the limit price rather than sharing market A. Thus, firm 1's choice between sharing and not sharing market A can be investigated by comparing its profit in the duopoly case with its profit when it is the only seller in market A selling at its limit price. Accordingly, firm 1 shares market A whenever

$$r_{2A} \le a(x_2 - x_1)(4 - x_1 - x_2) - d_2 t. \tag{5.3}$$

It adopts its limit price whenever (5.3) does not hold. Similarly, firm 2's best reply to r_{1A} in market A is given by

$$r_{2A} = \frac{1}{2}\left[r_{1A} - d_2 t + 2a(x_2 - x_1) - a\left(x_2^2 - x_1^2\right)\right], \tag{5.4}$$

whenever

$$r_{1A} \le a(x_2 - x_1)(2 + x_1 + x_2) + d_2 t. \tag{5.5}$$

Firm 2's best reply is given by

$$r_{2A} = \min\left\{r_{1A} - d_2 t - a\left(x_2^2 - x_1^2\right);\, v_2 - d_2 t\right\}, \tag{5.6}$$

when (5.5) does not hold. Hence, both firms share market A when (5.1) and (5.4) hold simultaneously. Solving these two equations, the equilibrium prices are

(5.7)
$$\tilde{r}_{1A} = \frac{a}{3}(x_2 - x_1)(2 + x_1 + x_2) + d_2\frac{t}{3},$$

(5.8)
$$\tilde{r}_{2A} = \frac{a}{3}(x_2 - x_1)(4 - x_1 - x_2) - d_2\frac{t}{3},$$

provided that

(5.9)
$$f = a(x_2 - x_1)(4 - x_1 - x_2) - d_2 t \geq 0,$$

(5.10)
$$a(x_2 - x_1)(2 + x_1 + x_2) + d_2 t \geq 0.$$

Obviously, (5.9) and (5.10) always hold when $d_2 = 0$. Thus, duopoly always arises when firms establish production in the same market. When $d_2 = 1$, only (5.10) always holds, indicating that either a duopoly arises in market A, or firm 1 is the only seller in that market. Clearly, firm 2 cannot monopolize market A when it produces in B. To be the only seller in any market, a firm must be able to undercut its rival's price. As an importer in A, firm 2 is unable to undercut firm 1's price since its minimum price in that market cannot be lower than t, and thus cannot be lower than the domestic firm's marginal cost (equal to zero here).[9] Hence, only firm 1, the domestic firm in A, can be the single seller in that market. This arises whenever (5.9) does not hold ($f < 0$), in which case firm 1's profit-maximizing price in market A is $\tilde{\tilde{r}}_{1A} = d_2 t + a(x_2^2 - x_1^2) - 2a(x_2 - x_1)$. A similar analysis holds for market B.

The following proposition summarizes the results for markets A and B.

PROPOSITION 1. *Given t, there exists a unique Nash price equilibrium in each market. In market A, it is given by*

$$\tilde{r}_{1A} = \frac{a}{3}(x_2 - x_1)(2 + x_1 + x_2) + d_2\frac{t}{3}; \qquad \tilde{r}_{2A} = \frac{a}{3}(x_2 - x_1)(4 - x_1 - x_2) - d_2\frac{t}{3},$$

whenever $f = a(x_2 - x_1)(4 - x_1 - x_2) - d_2 t \geq 0$ and by

$$\tilde{\tilde{r}}_{1A} = \min\{d_2 t + a(x_2^2 - x_1^2) - 2a(x_2 - x_1); v_1\} \qquad \tilde{\tilde{r}}_{2A} = 0,$$

whenever $f = a(x_2 - x_1)(4 - x_1 - x_2) - d_2 t < 0$. In market B, the price equilibrium is given by

$$\tilde{r}_{1B} = \frac{a}{3}(x_2 - x_1)(2 + x_1 + x_2) - d_2\frac{t}{3}; \qquad \tilde{r}_{2B} = \frac{a}{3}(x_2 - x_1)(4 - x_1 - x_2) + d_2\frac{t}{3};$$

[9] This is easily proved. Suppose firm 2 sets its price according to (5.6); firm 1's best reply is then given by (5.1) when (5.3) is satisfied. Solving (5.1) and (5.6) leads to $r_{1A} = 0$ and $r_{2A} = -d_2 t - a(x_2^2 - x_1^2)$ which is always negative given the assumptions of the model.

whenever $g = a(x_2 - x_1)(2 + x_1 + x_2) - d_2 t \geq 0$ *and by*

$$\tilde{\tilde{r}}_{1B} = 0; \qquad \tilde{\tilde{r}}_{2B} = \min\{d_2 t - a(x_2^2 - x_1^2); v_2\},$$

whenever $g = a(x_2 - x_1)(2 + x_1 + x_2) - d_2 t < 0$.

Note that Proposition 1 implies that a duopoly equilibrium in either market can arise irrespective of firm 2's market of production. However, an equilibrium in which market A or B has only one seller can only arise when firms produce in separate markets (i.e., $d_2 = 1$). Observe also that $\tilde{r}_{1A} = \tilde{\tilde{r}}_{1A}$ when $f = 0$ (similarly, $\tilde{r}_{2B} = \tilde{\tilde{r}}_{2B}$ when $g = 0$) and that these prices are differentiable with respect to x_1 and x_2 at $f = 0$ (at $g = 0$). Indeed, the firm's payoffs are *continuous and differentiable* in x_1 and x_2 for $x_1 \leq x_2 \in [0, 1]$. Finally, according to Proposition 1, when firms share both markets, the domestic price of a product is always at least as high as its corresponding foreign producer's price. Thus, the equilibrium exhibits reciprocal dumping (Brander and Krugman 1983).

In general, nothing prevents one firm from being the only seller in its domestic market while competing with its rival in the other market. Since markets are segmented and since there is no variable cost, the equilibrium prices reported in Proposition 1 also hold in this case. It is easy to describe both firms' payoffs conditional on x_1, x_2 and d_2. Let's denote by $\tilde{R}_{ij}(x_1, x_2, d_2)$ and $\tilde{\tilde{R}}_{ij}(x_1, x_2, d_2)$ the equilibrium gross profit of firm i in market j conditional on x_1, x_2 and d_2 when equilibrium prices are $\tilde{r}_{ij}$ and $\tilde{\tilde{r}}_{ij}$ respectively. Then, firm 1's payoffs are

$$(6) \qquad \pi_1^*(x_1, x_2, d_2)$$

$$= \begin{cases} \tilde{R}_{1A}(x_1, x_2, d_2) + \tilde{R}_{1B}(x_1, x_2, d_2) & \text{if } f \geq 0,\ g \geq 0; \\ \tilde{R}_{1A}(x_1, x_2, d_2 = 1) & \text{if } f \geq 0,\ g < 0; \\ \tilde{\tilde{R}}_{1A}(x_1, x_2, d_2 = 1) & \text{if } f < 0,\ g < 0; \\ \tilde{\tilde{R}}_{1A}(x_1, x_2, d_2 = 1) + \tilde{R}_{1B}(x_1, x_2, d_2 = 1) & \text{if } f < 0,\ g \geq 0. \end{cases}$$

Similarly, firm 2's payoffs are

$$(7) \qquad \pi_2^*(x_1, x_2, d_2)$$

$$= \begin{cases} \tilde{R}_{2A}(x_1, x_2, d_2) + \tilde{R}_{2B}(x_1, x_2, d_2) & \text{if } f \geq 0,\ g \geq 0; \\ \tilde{\tilde{R}}_{2B}(x_1, x_2, d_2 = 1) + \tilde{R}_{2A}(x_1, x_2, d_2 = 1) & \text{if } f \geq 0,\ g < 0; \\ \tilde{\tilde{R}}_{2B}(x_1, x_2, d_2 = 1) & \text{if } f < 0,\ g < 0; \\ \tilde{R}_{2B}(x_1, x_2, d_2 = 1) & \text{if } f < 0,\ g \geq 0. \end{cases}$$

Now that the equilibrium prices and corresponding payoffs conditional on product attributes and on markets of production have been determined, the optimal choices of x_1, x_2 and d_2 can be investigated.

4. PRODUCT ATTRIBUTES AND MARKET OF PRODUCTION

Despite the simple structure of the model, explicit solutions for x_1, x_2 and d_2 are not easy to find. Thus, I first investigate firm 2's choices of product attribute and market of production *conditional* on x_1, and then derive firm 1's profit-maximizing choice of x_1.

4.1. *Firm 2's Choice of Product Attribute.* Consider firm 2's choice of x_2 and d_2 for given x_1. Assuming $x_2 \geq x_1$, firm 2 maximizes $\pi_2^*(x_2, d_2; x_1)$ with respect to x_2 and d_2. Firm 2 faces five possible environments whose payoffs are given by (7). Consider first the choice of x_2 in each of these five environments taken *separately*. Proposition 2 then shows that a profit-maximizing firm, selecting x_2 over the five environments, will entirely avoid some of them.

LEMMA 1.

(i) *When firms share both markets and produce in the same market* ($f \geq 0$, $g \geq 0$, $d_2 = 0$), *firm 2 always chooses* $x_2 = 1$ *for all* $t/a \geq 0$ *and* $D_j \geq 0$.
(ii) *When firms share both markets and produce in separate markets* ($f \geq 0$, $g \geq 0$, $d_2 = 1$), *three outcomes are possible*: (a) *firm 2 selects* $x_2 = 1$; (b) *it chooses* x_2 *such that* $\min[f, g] = 0$; *or* (c) *it selects an attribute* $x_2 \in [.92, 1]$. *This last solution exists only when* $1 \leq D_A/D_B \leq 1.6$, $1.65 \leq t/a \leq 1.95$ *and* $0 \leq x_1 \leq .07$.
(iii) *When each firm sells only in its domestic market* ($f < 0$, $g < 0$), *firm 2 selects* $x_2 = x_1$ *with its limit price, and* $x_2 = 1/2$ *with its monopoly price.*
(iv) *When firm 2 shares its domestic market but does not sell in the other market* ($f < 0$, $g \geq 0$), *it forecloses trade by selecting* x_2 *such that* $g = 0$.
(v) *When firm 2 is the only seller in its domestic market and sells in the other market* ($f \geq 0$, $g < 0$), *it either chooses* x_2 *such that it does not trade* ($f = 0$) *or maximize differentiation in the range of* x_2 *consistent with* $f \geq 0$ *and* $g < 0$.

PROOF. See the Appendix.

Lemma 1 reveals two key forces which are central to the results of this paper: first, the incentive to differentiate products and in particular to *maximize* differentiation; second, the incentive to *imitate* product attribute.

Result (i) tells us that firm 2 always maximizes differentiation when both firms produce in the same market. This is a generalization of the result of d'Aspremont et al. (1979) since firm 2 chooses to maximize differentiation irrespective of t/a and D_A/D_B. Thus, result (i) completely describes firm 2's behavior for $d_2 = 0$.

When firms produce in separate markets ($d_2 = 1$), firm 2 can also imitate x_1. Clearly, product imitation is profitable for a relatively high t/a since it necessarily leads to a complete loss of the export market. It also depends on D_A/D_B since, with high D_A relative to D_B, firm 2 has an incentive to differentiate its product in order to export to the high density market.

Clearly, when $d_2 = 1$, high t/a and high D_A/D_B have conflicting effects on firm 2's choice of x_2. These conflicting forces can be found in results (ii) to (v). When both firms share both markets (result (ii)), firm 2 chooses to maximize differentiation when t/a is low and D_A/D_B is high. When t/a is high and D_A/D_B is low, it chooses to minimize differentiation by selecting x_2 consistent with $f \geq 0$ and $g \geq 0$ (i.e., x_2 such that $\min[f, g] = 0$). When both t/a and D_A/D_B are neither too low nor too high, firm 2 selects x_2 corresponding to a strictly interior local maximum where $f \geq 0$ and $g \geq 0$. This last result merits some additional explanations. To see why strictly interior solutions exist when firms share both markets and produce in separate markets, consider firm 2's domestic market only. Suppose furthermore that $D_A = D_B$. When t/a increases, firm 2 has an incentive to select x_2 closer to its rival's because it can increase its market share without having to decrease its price. An increase in t/a however gives the reverse incentive when it considers its export market only. The force determining location in the domestic market dominates since, with $t/a > 0$, domestic profit necessarily represents a greater share in total profits. Result (iic) shows that the sum of these two forces can give strictly interior solutions for x_2. They obviously require not too high or too low t/a and D_A/D_B since, if they are, maximum or minimum differentiation with $f \geq 0$ and $g \geq 0$ prevails.

In (iii) and (iv), firm 2 produces in B and does not export to market A. In both cases, it chooses to imitate firm 1's product attribute whether or not firm 1 exports. The proof of (iii) is immediate: since markets are covered and individual demands are inelastic, profit is maximized when firm 2's price is also maximized. It is the case at $x_2 = x_1$ when firm 2 uses its limit price, and at $x_2 = 1/2$ when it uses its monopoly price v_2.

Finally, in (v), firm 2 exports to A but firm 1 does not. In this case, firm 2 again either maximizes differentiation or minimizes it in the range of x_2 consistent with $f \geq 0$ and $g < 0$.

Given the profit-maximizing product attribute of firm 2 in each of these environments, firm 2's optimal choices can be determined.

PROPOSITION 2.

(i) *When firm 2 sells in both markets, it selects* $x_2 = 1$ *and when it does not, it chooses* $x_2 = x_1$ *or* $x_2 = 1/2$.

(ii) *Given* $x_2 \geq x_1$, *firm 2 chooses* $d_2^* = 0$ *and* $x_2^* = 1$ *whenever* $\pi_2(x_2^* = 1, d_2^* = 0;\ x_1) > \max[\pi_2(x_2^* = 1,\ d_2 = 1;\ x_1); \pi_2(x_2^* = x_1,\ d_2 = 1;\ x_1)]$. *This arises whenever*

$$(9)\quad \frac{t}{a} < \min\left[\frac{1}{18}\left(\frac{D_A}{D_B}+1\right)(1-x_1)(3-x_1)^2; 2\left(\frac{D_A - D_B}{D_A + D_B}\right)(1-x_1)(3-x_1)\right].$$

Firm 2 chooses $d_2^* = 1$ *otherwise. In this case, it selects* $x_2^* = 1$ *whenever* $\pi_2(x_2^* = 1,\ d_2^* = 1; x_1) > \pi_2(x_2^* = x_1,\ d_2^* = 1;\ x_1)$, *which holds when*

$$(10) \qquad \frac{t}{a} < \frac{(1-x_1)}{D_A + D_B}\left\{K_1 - \left[K_1^2 - (D_A + D_B)^2(3 - x_1)^2\right]^{1/2}\right\},$$

where $K_1 = 9D_B + (3 - x_1)(D_A - D_B)$. *Firm 2 selects* $x_2^* = x_1$ *otherwise.*

PROOF. See the Appendix.

The first part of Proposition 2 indicates that firm 2 follows one of three possible strategies: it shares both markets by producing in the same market as firm 1 and maximizes differentiation; it shares both markets by producing in a different market than firm 1 and also maximizes differentiation; it imitates product 1's attribute. The second part of the proposition characterizes firm 2's choices as a function of the parameters of the model. It makes clear the trade off faced by firm 2 between a protected and a high density market. When $D_A = D_B$, (9) never holds so that firm 2 always chooses to produce in market B. Market B is preferred because, with positive t/a, competition is always less intense when firms produce in separate markets than when they produce in the same market. Whether it differentiates its product or imitates x_1 depends then only on t/a. If it is high (see (10)), firm 2 chooses product imitation, and if it is low, it maximizes differentiation. Establishing production in the same market as firm 1 (market A) becomes profitable only when $D_A > D_B$ and when t/a is low.

Firm 2's choices of x_2 can be illustrated by plotting π_2 for all feasible $x_2 \in [0, 1]$. This is done in Figure 1a to 1d for various tariff rates when $D_A = D_B = 1$, $a = 1$, $v = 3$ and when $x_1 = 0$ or $x_1 = 1/2$. Figure 1a, valid for all t when $d_2 = 0$ and only for $t = 0$ when $d_2 = 1$, clearly shows that firm 2 maximizes differentiation regardless of x_1. When $d_2 = 1$, Figures 1b to 1d show that firm 2 either shares both markets, in which case maximum differentiation occurs, or else selects $x_2 = x_1$. In particular, product imitation dominates whenever $t \geq 1.146a$.[10]

4.2. *Firm 1's Choice of Product Attribute and Nash Equilibrium.* Consider now firm 1's choice of product attribute. The analysis is carried out in two steps: first, I consider the choice of x_1 when firm 1 takes x_2 and d_2 as given, and then I investigate the effects of firm 1's first-mover advantage on its choice of x_1.

Clearly, firm 1, being identical to firm 2, faces the same incentive as firm 2 when it takes d_2 and x_2 as given. Thus, like firm 2, firm 1 maximizes differentiation when

[10] In each of these figures, critical points $\tilde{x}_{21}$ and $\tilde{x}_{22}$ represent firm 2's product attribute below which firm 1 and firm 2 respectively cannot trade given x_1 and t. Thus, firm 2 monopolizes its domestic market and exports when $\tilde{x}_{22} < x_2 < \tilde{x}_{21}$ for $x_2 \geq x_1$, and firm 2 shares its domestic market without exporting when $\tilde{x}_{21} < x_2 < \tilde{x}_{22}$ for $x_2 \geq x_1$. These possibilities are never selected by firm 2 (similarly when $x_1 \geq x_2$ with respect to $(1 - \tilde{x}_{21})$ and $(1 - \tilde{x}_{22})$).

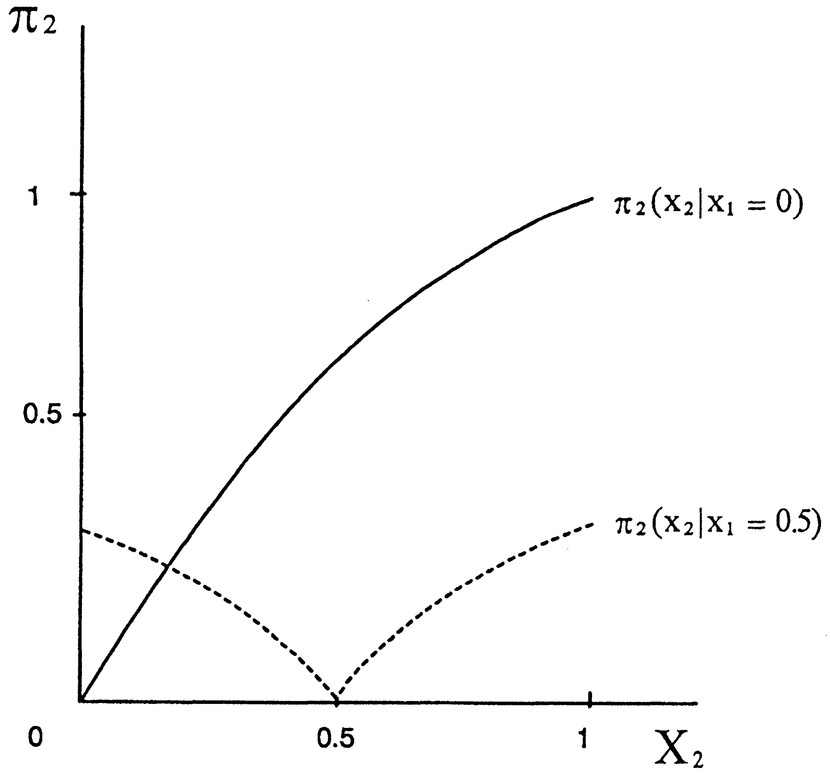


FIGURE 1a

CHOICE OF x_2 FOR $t = 0$

$d_2 = 0$ and it never lets firm 2 have a share of its domestic market when it cannot share market B ($f \geq 0$ and $g < 0$). Also, firm 1 always prefers either to share both markets or to sell only in its domestic market rather than being the only seller in its domestic market while keeping a share of the other market ($f < 0$ and $g \geq 0$). This is the case since with $D_A \geq D_B$, it must be at least as costly for firm 1 as it is for firm 2 to deviate from product imitation in order to export.

There are two differences in behavior between firm 1 and firm 2. They arise naturally from $D_A > D_B$. The first one exists when firms produce in different markets ($d_2 = 1$) and share both of them ($f \geq 0$ and $g \geq 0$). In that case, firm 1 chooses strictly interior solutions for parameters that still induce firm 2 to maximize differentiation. In effect, selling in the foreign market (a force pushing firms to differentiate their product) has a decreasing importance on firm 1's profit as D_A/D_B rises, whereas it has an increasing influence on firm 2's profit. The second difference arises with product imitation ($f < 0$ and $g < 0$). Because the share of domestic profit in total profit is greater for firm 1 than it is for firm 2 when $d_2 = 1$ and $D_A > D_B$, firm 1 always has a *stronger* incentive to use product imitation than firm 2. Despite

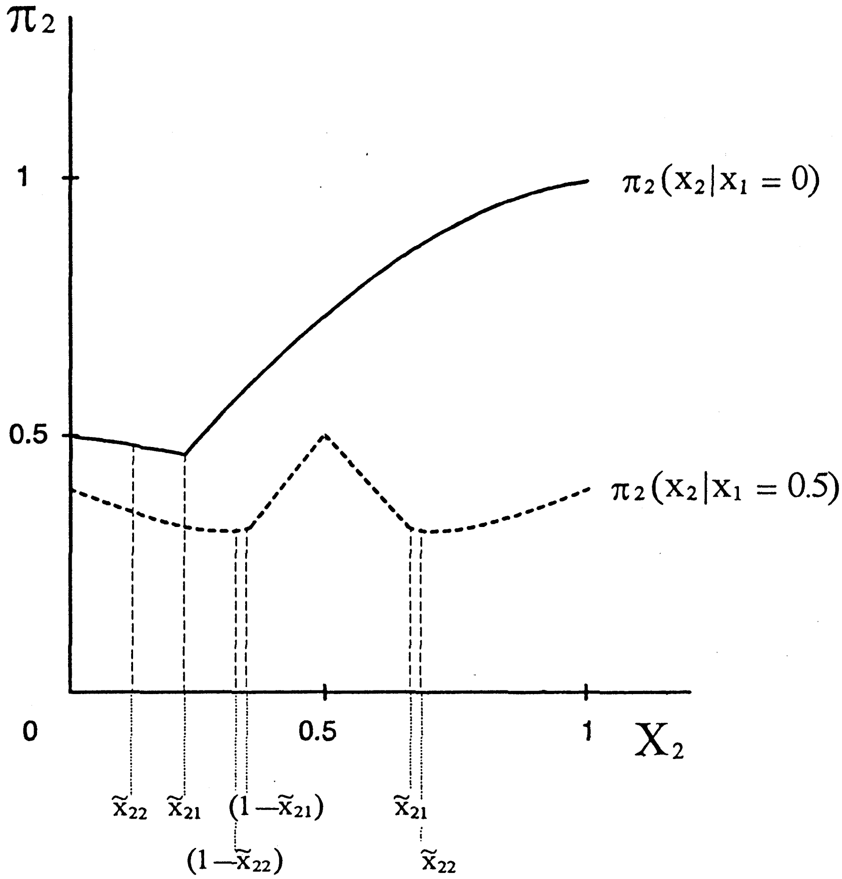


FIGURE 1b

CHOICE OF x_2 FOR $t = 0.5$

these differences, firm 1's behavior is straightforward. Proposition 3 summarizes the results.

PROPOSITION 3. *Firm* 1, *taking* d_2 *and* x_2 *as given, either maximizes differentiation or matches firm* 2*'s product attribute. If* $d_2 = 0$, *it always selects* $x_1^* = 0$, *and if* $d_2 = 1$, *it selects*

$$(11)\quad x_1^* = \begin{cases} 0, & \text{when } \dfrac{t}{a} < \dfrac{x_2}{D_A + D_B}\left\{K_2 - \left[K_2^2 - (D_A + D_B)^2(2 + x_2)^2\right]^{1/2}\right\}, \\ x_2, & \text{otherwise,} \end{cases}$$

where $K_2 = 9D_A - (D_A - D_B)(2 + x_2)$.

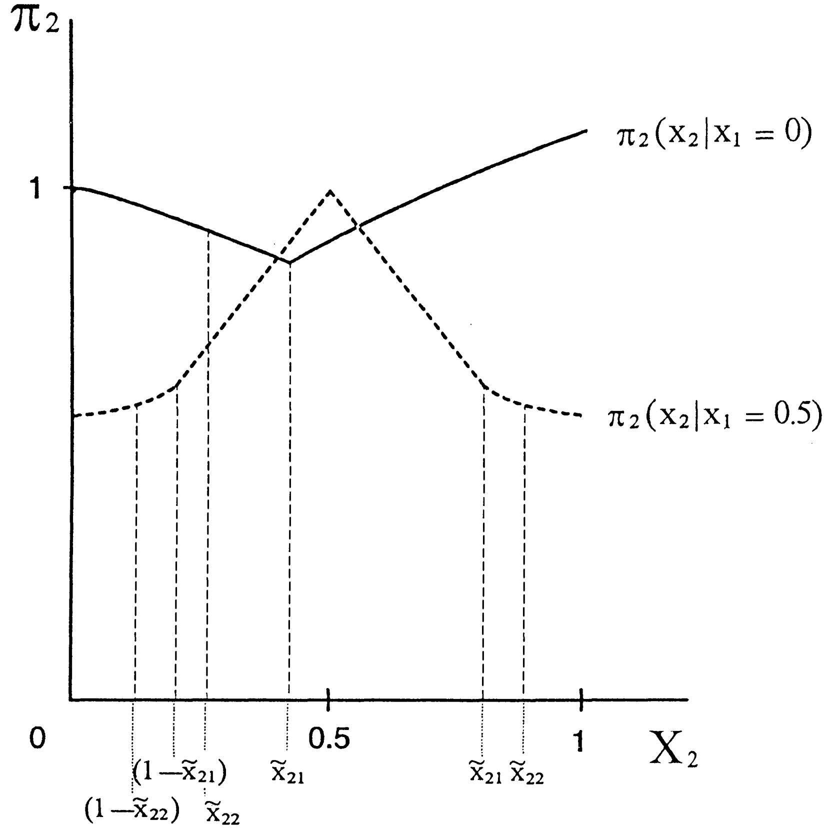


FIGURE 1c

CHOICE OF x_2 FOR $t = 1.0$

PROOF. See the Appendix.

Obviously, firm 1's incentive to imitate x_2 is sufficiently strong to dominate any incentive to differentiate its product and to select strictly interior solutions when firms share both markets. The Nash equilibrium in x_1, x_2 and d_2 can now be characterized by combining the results of Propositions 2 and 3.

PROPOSITION 4. *With two firms, the triplet* $(x_1^* = 0,\ x_2^* = 1,\ d_2^* = 0)$ *is a Nash equilibrium whenever*

$$\frac{t}{a} < \min\left[\frac{1}{2}\left(\frac{D_A}{D_B}+1\right);\ \frac{6(D_A - D_B)}{D_A + D_B}\right]. \tag{12}$$

When this condition does not hold, the triplet $(x_1^* = 0,\ x_2^* = 1,\ d_2^* = 1)$ *is a Nash*

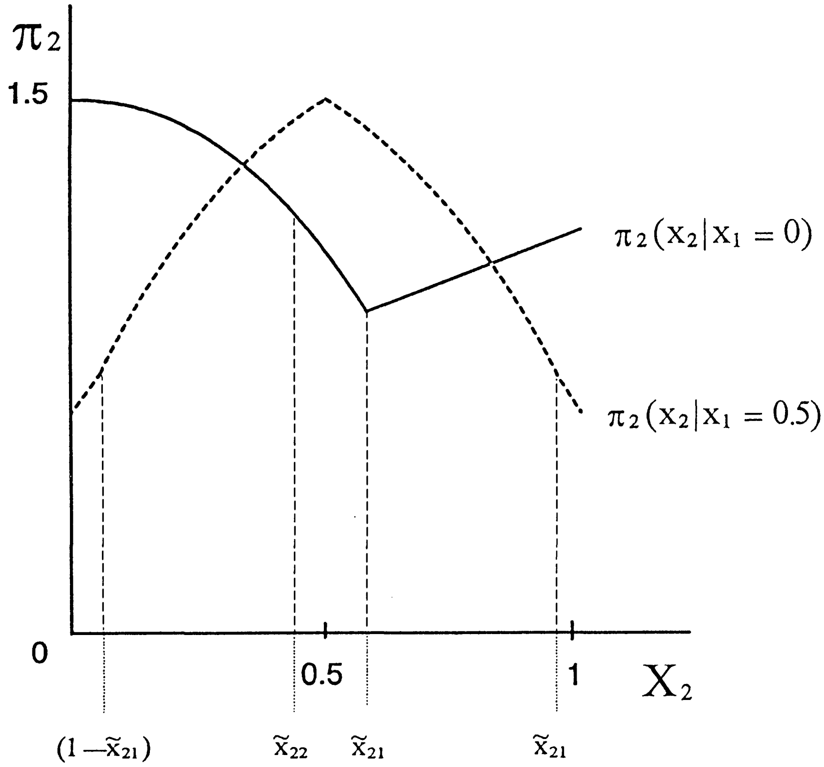


FIGURE 1d

CHOICE OF x_2 FOR $t = 1.5$

equilibrium whenever

$$\frac{t}{a} < \frac{3}{\frac{D_A}{D_B}+1}\left\{2\frac{D_A}{D_B}+1-\left[\frac{D_A}{D_B}\left(3\frac{D_A}{D_B}+2\right)\right]^{1/2}\right\}, \tag{13}$$

and ($x_1^* = x_2^*$, $d_2^* = 1$) *is a Nash equilibrium whenever*

$$\frac{t}{a} > \frac{3}{\frac{D_A}{D_B}+1}\left[2+\frac{D_A}{D_B}-\left(3+2\frac{D_A}{D_B}\right)^{1/2}\right]. \tag{14}$$

Condition (12) comes directly from (9) for $x_1^* = 0$, $x_2^* = 1$ and $d_2^* = 0$, and conditions (13) and (14) correspond respectively to (11) and (10) for $x_1^* = 0$, $x_2^* = 1$ and $d_2^* = 1$.

Figure 2 illustrates Proposition 4. The space $(t/a, D_A/D_B)$ is divided into four areas separated by segments GIJ, KH and KI corresponding respectively to (12), (13) and (14). The triangle KIH delimits pairs $(t/a, D_A/D_B)$ for which there is no equilibrium in pure strategies. In that case, firm 2 producing in market B finds it more profitable to *maximize* differentiation with respect to x_1, whereas firm 1 wants to imitate x_2 even when $x_2 = 1$.[11] When equilibria in pure strategies do exist, three equilibrium configurations are possible depending on t/a and D_A/D_B: product imitation and no trade ($d_2^* = 1$, $x_1^* = x_2^*$), duopoly with two-way trade ($d_2^* = 1$, $x_1^* = 0$, $x_2^* = 1$), and duopoly with one-way trade ($d_2^* = 0$, $x_1^* = 0$, $x_2^* = 1$).

Clearly, even with simultaneous choice of x_1, x_2 and d_2, there is a large scope for profitable product imitation. Surprisingly, the range of parameter values for which firms share both markets while producing in different markets (two-way trade) is quite small. Two forces constrain it: an *agglomeration* effect induced by asymmetric market size and a *monopolization* effect through product imitation induced by protection.[12] Finally, Figure 2 shows that changes in parameters either have no effect on product choices or have radical effects, bringing the equilibrium to very different configurations.

4.3. *First-Mover Advantage and Equilibrium.* Suppose now that firm 1 has a first-mover advantage in its choice of x_1. Firm 1's problem is thus

$$(15) \qquad \max_{x1} \quad \pi_1^*(x_1, x_2^*(x_1), d_2^*(x_1)),$$

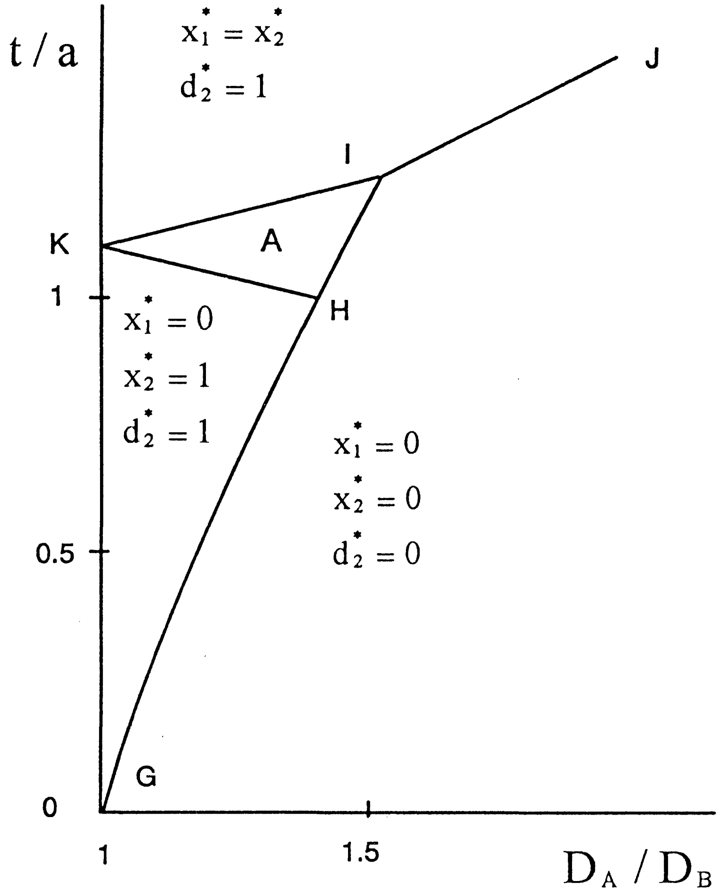
where $x_2^*(x_1)$ and $d_2^*(x_1)$ are firm 2's best response functions with respect to x_1.

RESULT 1. As compared to the Nash equilibrium with simultaneous moves, a first-mover advantage in x_1

(i) increases the range of parameters where product imitation takes place;
(ii) increases the range of parameters where two-way trade occurs by making optimal strictly interior solutions for x_1^* (i.e., $x_1^* > 0$);
(iii) decreases the range of parameters where both goods are produced in the same market.

[11] A mixed strategy equilibrium exists in triangle KIH. To see this, observe first that, in each market j $(j = A, B)$, the second stage involving price competition has a unique profile of actions (r_{1j}, r_{2j}) that are mutual best responses (see Proposition 1). Second, in the stage involving the choice of product attributes, there is a mixed profile of actions (x_1, x_2) that are also mutual best responses since the conditions of the Fan-Glicksberg theorem apply (Fudenberg and Tirole 1992). The profile of mixed strategies given by $(x_1, r_{1j}(x_1, x_2), x_2, r_{2j}(x_1, x_2))$ is then an equilibrium. To see the nature of the mixed strategies, consider an example. Let $D_A/D_B = 1.1$ and $t/a = 1.14$ be a point in KIH. In this case, firm 1's best response is to maximize differentiation if it cannot match x_2. Similarly, if firm 2 cannot maximize differentiation, its best response is to imitate x_1. Hence, both firms mix (with probability $1/2$) between locating their product at the two end points of the unit interval in their respective market of production.

[12] Note that the degree of substitution between products as captured by the parameter a also influences the scope for two-way trade: higher values of a imply greater disutility in consuming a product with a different attribute than most preferred and thus higher duopoly equilibrium prices. The scope for product imitation is then lessened increasing the scope for two-way trade.



A: Mixed Strategy Equilibria

FIGURE 2

NASH EQUILIBRIA WITH SIMULTANEOUS ENTRY

The range of parameters where product imitation occurs increases for two reasons. First, the range of parameters with no equilibrium in pure strategies disappears as firm 1 can always enforce product imitation as its preferred outcome. Recall that with simultaneous moves no pure strategy equilibrium existed in the triangle KIH of Figure 2 because firm 1's incentive was to imitate whereas firm 2's incentive was to maximize differentiation. With a first-mover advantage, firm 1 is now able to enforce its preferred outcome simply because there always exist $x_1 \in [0, 1/2]$ such that firm 2's best response is to imitate x_1.[13] Second, product

[13] Note that firm 2 never chooses $d_2^* = 0$ in response to $x_1^* > 0$ when $d_2^* = 1$ is firm 2's best response to $x_1 = 0$ (see (9)).

imitation is also more prevalent because firm 1 can now select x_1^* such that firm 2 is forced to choose $d_2^* = 1$ and $x_2^* = x_1$ instead of $d_2^* = 0$ and $x_2^* = 1$. Firm 1 prefers this strategy whenever $\pi_1^*(x_1^* = x_2;\ x_2, d_2^* = 1) \geq \pi_1^*(x_1^* = 0;\ x_2^* = 1,\ d_2^* = 0)$ which holds whenever $t/a \geq 1/2(1 + D_B/D_A)$. Clearly, this strategy becomes more attractive as D_A/D_B rises since firm 1 is the only seller in the high density market. Similarly, firm 2 chooses $d_2^* = 1$ and $x_2^* = x_1$ whenever $\pi_2^*(x_2^* = x_1,\ d_2^* = 1; x_1) \geq \max[\pi_2^*(x_2^* = 1,\ d_2 = 0; x_1);\ \pi_2^*(x_2^* = 1,\ d_2^* = 1; x_1)]$. Hence, with (9) and (10), firm 1 forces $d_2^* = 1$ (instead of $d_2^* = 0$) with maximum differentiation or product imitation whenever

$$(16)\qquad \frac{t}{a} \geq \max\begin{cases} \dfrac{1}{2}\left(1 + \dfrac{D_B}{D_A}\right) \\ \dfrac{1}{18}\left(1 + \dfrac{D_A}{D_B}\right)(1 - x_1)(3 - x_1)^2; \\ \dfrac{1 - x_1}{D_A + D_B}\left\{K_1 - \left[K_1^2 - (D_A + D_B)^2(3 - x_1)^2\right]^{1/2}\right\}\Bigg], \end{cases}$$

where $K_1 = 9D_B + (3 - x_1)(D_A - D_B)$.

Consider now Result 1 (ii). With two-way trade, firm 1 no longer necessarily maximizes differentiation. Indeed, the first-mover advantage makes strictly interior solutions for x_1 optimal when it forces firm 2 to choose $d_2^* = 1$ instead of $d_2^* = 0$. In this case, firm 2 still maximizes differentiation as it did when $d_2^* = 0$. Firm 1 selects an interior solution resulting in two-way trade whenever

$$(17.1)\quad \pi_1^*(x_1 > 0;\ x_2^* = 1,\ d_2^* = 1) \geq \max\left[\pi_1^*(x_1^* = 0,\ x_2^* = 1,\ d_2^* = 0);\ \pi_1^*(x_1^* = x_2^*, x_2^*, d_2^* = 1)\right];$$

$$(17.2)\quad \pi_2^*(x_2^* = 1,\ d_2^* = 1;\ x_1 > 0) \geq \max\left[\pi_2^*(x_2^* = 1,\ d_2^* = 0;\ x_1 > 0);\ \pi_2^*(x_2^* = x_1^*,\ d_2^* = 1;\ x_1 > 0)\right].$$

Finally, since there are three possible equilibrium configurations and the scope of two of them rises, the scope for the third one (firms maximize differentiation and produce in the same market) must necessarily decrease (Result 1 (iii)).

Figure 3 illustrates the different equilibrium configurations when firm 1 has a first-mover advantage. Consider for instance $D_A/D_B = 1$. In that case, firm 2 always establishes production in market B, and both firms maximize differentiation ($x_1^* = 0$; $x_2^* = 1$) when $t < 1.15$ and match their product otherwise ($x_1^* = x_2^*$). When $D_A/D_B > 1$, two effects occur: first, firm 2 has an incentive to establish production in the high density market for an increasing range of t. Second, firm 1 has an incentive to force firm 2 to establish production in market B. To illustrate firm 1's incentive, consider two examples, one where firm 1 forces two-way trade and one where it forces product imitation. When $t = .6$ and $D_A/D_B = 1.3$, firm 1 selects the

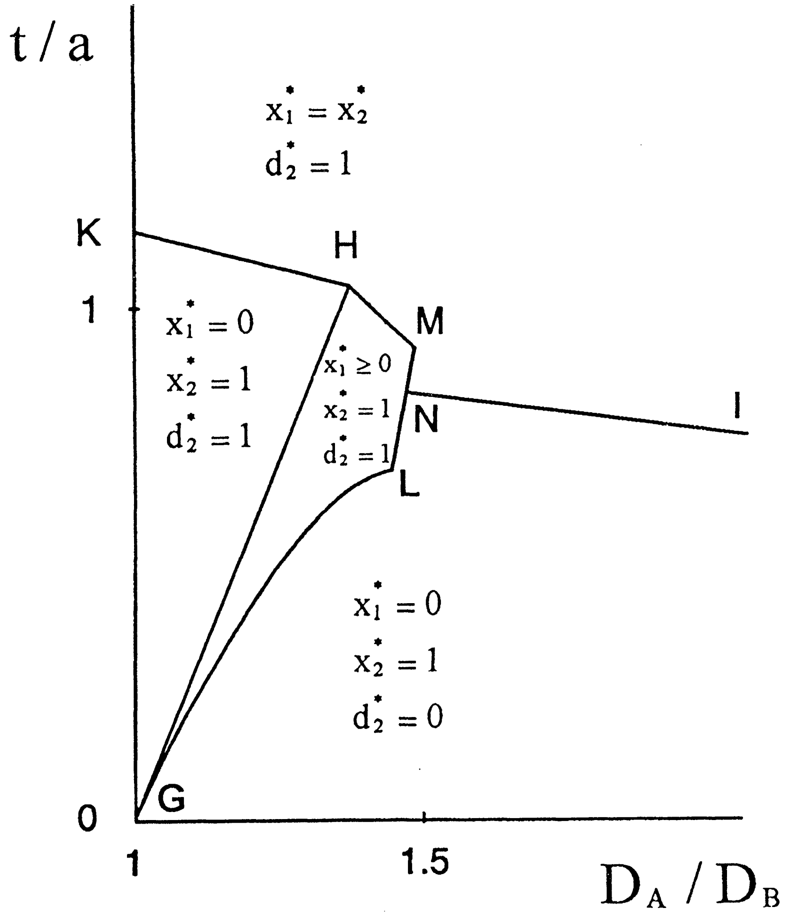


FIGURE 3

NASH EQUILIBRIA WITH SEQUENTIAL ENTRY

interior solution $x_1^* = .2$ rather than $x_1 = 0$. This forces firm 2 to establish production at $x_2^* = 1$ in market B rather than in market A. In contrast, firm 1 accommodates firm 2 in A when $D_A/D_B < 1.3$ and $t = .6$. Instead of inducing two-way trade, firm 1 can also induce firm 2 to produce in B by forcing product imitation. When $t = 1.0$, $D_A/D_B = 1.5$ and $x_1 = 0$, firm 2's best response is $x_2^* = 1$ in A and both firms earn $\pi_1^* = 1.25$. By selecting $x_1^* = \frac{1}{2}$, firm 1 forces firm 2 to match and it earns $\pi_1^* = 1.5$.

As a result of these various forces, the space $(t/a, D_A/D_B)$ is still divided in four areas: KHG, identical to Figure 2, captures the range of parameters where duopoly with two-way trade and maximum differentiation prevails. This area is now augmented by GHMNL where two-way trade has strictly interior solutions for x_1^*. The scope for product imitation increases significantly with respect to Figure 2 as the locus KHMNI, determined by conditions (16) and (17), now separates product imitation from the other possible configurations.

Figure 3 shows that the equilibrium configurations are quite sensitive to asymmetric consumer's densities and protection. In particular, similar market size alone is not sufficient to generate two-way trade since barriers to trade must also be low. Two-way trade completely disappears as soon as $D_A/D_B \geq 1.5$ irrespective of t/a, and it never occurs for $t/a \geq 1.15$ irrespective of $D_A/D_B \geq 1$. Among the equilibrium configurations, product imitation is a strong force since it depends mainly on t/a.

It is worthwhile to come back to the assumption about firm 1's market of production. The claim is that, given $D_A/D_B \geq 1$, firm 1 would not produce in market B when free to do so. Clearly, when both firms share both markets or when each market has one seller, firm 1 never earns a higher profit by locating in B rather than in A. However, there certainly exist circumstances where firm 1 earns a higher profit by being the only seller in the small market rather than sharing the large one. Even in this case, firm 1 does not locate in B. The reason is simple; with $D_A \geq D_B$ and symmetric firms, it is necessarily more profitable for firm 1 to be the only seller in A rather than sharing both markets when it is indifferent between being the only seller in B and sharing both markets.

The results of this paper are clear cut in part because the number of potential firms does not exceed the number of markets. However, product imitation and product differentiation will also exist in a game with more firms than markets. To see this suppose that the markets can sustain many products. Clearly early entrants have an incentive to differentiate their product: not only can they take advantage of the extent of the market, but they also want to avoid inducing product imitation by later entrants. As long as t/a is positive, later entrants still have an incentive to imitate existing imported products. Indeed either they differentiate their product, sell in both markets and drive down the equilibrium prices of close substitutes, or they simply *replace* an imported product by a domestic one. In the latter case, the equilibrium price in the domestic market either remains the same because the newcomer sells at its limit price or decreases slightly because the domestic entrant can be more aggressive than the imported product it replaces. This import substitution mechanism makes entry still profitable when product differentiation does not because it makes entry possible without increasing the number of products in that market. Clearly, product imitation will also exist in a game with more firms than markets.

5. CONCLUSIONS

In this paper, I have combined the spatial approach to product differentiation and games of simultaneous and sequential entry in an international trade environment with two markets. By deriving the market of production of each firm and its product attribute, both the equilibrium market structure and the pattern of trade are determined. With two firms at most, product imitation and product differentiation have been shown to be both consistent with the international equilibrium.

The picture that emerges from the analysis is that product differentiation is associated with market penetration and market sharing, while product imitation and monopoly are associated with market defense and market separation. The international barriers to trade and the size of each market are the two key elements which determine the equilibrium product configuration. Product imitation is not possible without barriers to trade and it is made easier by asymmetric market size. This is the case because the first mover, producing in the high-density market, has an incentive to force the second mover to the low density market. Note that the barriers to trade do not have to be high for product imitation to emerge. Moreover, the analysis does not need to be restricted to two firms for these forces to exist.

Although the analysis has been restricted to a model where firms produce in a single market only, the predictions of the model fit well with the behavior of the microbrewers in British Columbia which associate their products with German beers. The analysis is also consistent with trade disputes such as the one between France and Canada about the use of the word "champagne" by Canadian producers of sparkling wine. Had transport costs and/or tariffs been lower, market penetration and market sharing might have prevailed, forcing the Canadian producers into niches that clearly differentiate their products from existing ones. The aircraft industry might be another example where head-to-head competition and similarity of products are preferred. In addition to Klemperer (1992)'s explanation, this is due, in part, to trade protection and in part to a buyers' bias for national products. In contrast, the watch industry, as well as other consumer durables better fit the product differentiation equilibrium.

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APPENDIX

PROOF OF LEMMA 1. (i) Maximizing $\tilde{R}_{2A} + \tilde{R}_{2B}$ (see (7)) with respect to x_2 when $d_2 = 0$, the first-order condition is

$$\frac{\partial \pi_2^*}{\partial x_2} = \frac{1}{18}(D_A + D_B)(4 - 3x_2 + x_1)(4 - x_2 - x_1),$$

which is always strictly positive whatever $x_i \in [0,1]$, $i = 1,2$.

(ii) The first-order condition in x_2 cannot be solved directly; we thus proceed indirectly. Compare first firm 2's profit level at $x_2 = 1$ with its level at x_2 such that $\min[f, g] = 0$. Firm 2 chooses

$$\text{(A.1)} \qquad x_2 = \begin{cases} 1, & \text{if } 0 \le \dfrac{t}{a} \le t_g, \\ -1 + \left[(x_1+1)^2 + \dfrac{t}{a}\right]^{1/2}, & \text{if } t_g \le \dfrac{t}{a} \le 3(1 - 2x_1), \end{cases}$$

provided that $x_1 + x_2 \leq 1$, and $x_1 \leq x_2 \in [0,1]$, and

$$\text{(A.2)} \qquad x_2 = \begin{cases} 1, & \text{if } 0 \leq \dfrac{t}{a} \leq t_f, \\ 2 - \left[(2-x_1)^2 - \dfrac{t}{a}\right]^{1/2}, & \text{if } t_f \leq \dfrac{t}{a} \leq (3-x_1)(1-x_1), \end{cases}$$

provided that $x_1 + x_2 \geq 1$ and $x_1 \leq x_2 \in [0,1]$. Both t_g and t_f depend on D_A/D_B and x_1; both are increasing in D_A/D_B. Given x_1, compute now $\tilde{t}/a$ such that firm 2's profit is maximized at $x_2 = 1$. Local interior solutions in x_2 where firms share markets exist only for $t/a > \tilde{t}/a$. Thus, (A.1) and (A.2) describe firm 2's choice of x_2 as long as $\tilde{t}/a > t_g$ and $\tilde{t}/a > t_f$ respectively. Otherwise, $x_2 \leq 1$ is possible. Using numerical procedures, $\tilde{t}/a \leq t_g$ only when $1 \leq D_A/D_B \leq 1.6$; $1.65 \leq t/a \leq 1.95$ and $0 \leq x_1 \leq .07$. In this case, $.92 \leq x_2 \leq 1$.

(iii) See the text.

(iv) Maximizing $\tilde{R}_{2B}$ in (7) with respect to x_2, we must show that

$$\frac{\partial \pi_2^*}{\partial x_2} = \frac{D_B}{18a(x_2 - x_1)^2}\left[a(x_2 - x_1)(4 - x_2 - x_1) + t\right] \times \left[a(x_2 - x_1)(4 - 3x_2 + x_1) - t\right]$$

is negative. Since $a(x_2 - x_1)(4 - x_2 - x_1) + t \geq 0$ for $x_2 \geq x_1 \in [0,1]$ and $t \geq 0$, the sign of $\partial \pi_2^*/\partial x_2$ depends on the sign of $[a(x_2 - x_1)(4 - 3x_2 + x_1) - t]$. When $f < 0$, $t > a(x_2 - x_1)(4 - x_1 - x_2)$ and $(4 - x_1 - x_2) > (4 - 3x_2 + x_1)$; hence, $[a(x_2 - x_1)(4 - 3x_2 + x_1) - t] < 0$.

(v) We first show that firm 2 adopts its limit price in B. To see this, define $\hat{t} = a(x_2 - x_1)(4 - x_1 - x_2)$ as the highest possible t consistent with $f \geq 0$ and $g < 0$. Firm 2 chooses its limit price whenever $\hat{t} - a(x_2^2 - x_1^2) \leq v - a\max[x_2^2, (1-x_2)^2]$. This inequality holds when $v \geq 3a$ and $(x_1 + x_2) < 1$. The first inequality must hold for both markets to be covered and the second one always holds when $f \geq 0$ and $g < 0$. Second, given this result, $\partial \pi_2/\partial x_2 < 0$ when evaluated at x_2 such that $f = 0$. Evaluated at the other extreme of the range, $\partial \pi_2/\partial x_2$ can be positive or negative. Using numerical procedures, we find only one inflexion point between these two limits. Hence, firm 2 selects a corner solution in the range of x_2 consistent with $f \geq 0$ and $g < 0$.

Proof of Proposition 2 (i). (a) When $d_2 = 0$, $x_2^* = 1$ by Lemma 1.

(b) Suppose now $d_2 = 1$. (1) Consider $f \geq 0$, $g \geq 0$ and x_2 such that $\min[f, g] = 0$. At these locations, $\partial \pi_2/\partial x_2 < 0$. Since π_2 is continuous and differentiable, firm 2 has a marginal incentive to choose x_2 either in the range where $g < 0$ or where $f < 0$. (2) When $f < 0$ and $g \geq 0$, firm 2 chooses x_2 such that $g = 0$ (Lemma 1). Since $\partial \pi_2/\partial x_2 < 0$ when evaluated at this attribute, firm 2 prefers x_2 such that $g < 0$, and by Lemma 1, $x_2^* = x_1$ or $x_2^* = 1/2$. (3) When $f \geq 0$ and $g < 0$, two product attributes are possible: x_2 such that $f=0$ or x_2 such that $g=0$. In the first case, $\partial\pi_2/\partial x_2<0$ implying that firm 2 prefers x_2 such that $f<0$ and thus, by Lemma 1, $x_2^*=x_1$ or $x_2^*=1/2$. In the second case, $\partial\pi_2/\partial x_2>0$ in the neighborhood of this location; thus firm 2 prefers x_2 such that $f\geq 0$ and $g\geq 0$. Thus, the optimal choice of x_2 is either such that both firms share both markets ($f\geq 0$, $g\geq 0$) or that they do not trade at all ($f<0$, $g<0$).

(c) We now want to show that the interior solutions found when $f\geq 0$ and $g\geq 0$ are never selected. To do so, find t_1 such that $\tilde{\tilde{R}}_{2B}(x_2=x_1, d_2=1; x_1)\geq \tilde{R}_{2A}(x_2, d_2=1; x_1)+\tilde{R}_{2B}(x_2, d_2=1; x_1)$ for $t/a\geq t_1$; that is, product imitation without trade is preferred to product differentiation with trade. Assuming $D_B=1$, we find

$$t_1=\frac{(x_2-x_1)}{1+D_A}\{5+x_1+x_2+D_A(4-x_1-x_2) - [1+2(x_1+x_2)]^{1/2}[9+8D_A-2D_A(x_1+x_2)]^{1/2}\}.$$

Observe that $\partial t_1/\partial x_2>0$ and $\partial t_1/\partial x_1<0$ whatever $D_A\geq 1$ and $x_1, x_2\in[0,1]$. Hence, given D_A, the highest value of t_1 above which imitation is preferred is always found for $x_1=0$ and $x_2=1$. When $D_A=1$, $t_1=1.1453$ and when $D_A=2$, $t_1=1.354$; thus, given D_A/D_B, the highest value of t_1 is always smaller than t/a for which interior solutions in x_2 are found. Thus, when $f\geq 0$ and $g\geq 0$, $x_2^*=1$.

PROOF OF PROPOSITION 3. Suppose $d_2=1$, $f\geq 0$ and $g\geq 0$ and compare firm 1's profit at $x_1=0$ with its level at x_1 such that $\min[f,g]=0$. Firm 1 chooses

$$x_1=\begin{cases} 0, & \text{if } 0\leq \dfrac{t}{a}\leq t'_g \\ -1+\left[(1+x_2)^2-\dfrac{t}{a}\right]^{1/2} & \text{if } t'_g\leq \dfrac{t}{a}\leq 3(2x_2-1) \end{cases} \quad \text{(A.3)}$$

provided that $x_1+x_2\leq 1$ and $x_1\leq x_2\in[0,1]$, and

$$x_1=\begin{cases} 0, & \text{if } 0\leq \dfrac{t}{a}\leq t'_f, \\ 2-\left[(2-x_2)^2+\dfrac{t}{a}\right]^{1/2}, & \text{if } t'_f\leq \dfrac{t}{a}\leq x_2(2+x_2), \end{cases} \quad \text{(A.4)}$$

provided $x_1+x_2\geq 1$ and $x_1\leq x_2\in[0,1]$. Calculate now $\tilde{t}'/a$ such that firm 1's profit is at a local maximum at $x_1=0$. Local interior maximum for x_1 will exist for $t/a>\tilde{t}'/a$ only. Thus, (A.3) and (A.4) describe firm 1's choice of x_1 as long as

$\tilde{t}'/a \geq t'_g$ and $\tilde{t}'/a \geq t'_f$ respectively. Using numerical methods, $\tilde{t}'/a \leq t'_f$ only for $D_A/D_B \geq 1$; $.94 \leq t/a \leq 1.78$ and $.75 \leq x_2 \leq 1$. Within these ranges, $0 \leq x_1 \leq .23$. I checked that product imitation always dominates these interior solutions (i.e., $\pi_1^*(x_1^* = x_2, x_2, d_2 = 1) > \pi_1(x_1 > 0, x_2, d_2 = 1)$). Since $\partial \pi_1/\partial x_1 > 0$ when $t/a \geq t'_g$ or $t/a \geq t'_f$, $x_1^* = 0$ is the only firm 1's equilibrium location when $f \geq 0$ and $g \geq 0$. Thus, like firm 2, firm 1 either chooses $x_1^* = 0$ when $f \geq 0$ and $g \geq 0$ or $x_1^* = x_2$ when $f < 0$ and $g < 0$. Finally, to find (11), simply calculate t/a such that $\pi_1^*(x_1^* = 0, x_2, d_2 = 1) = \pi_1^*(x_1^* = x_2, x_2, d_2 = 1)$.

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