Product Line Rivalry

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Most firms offer entire product lines rather than single products. There is, however, only a relatively small body of literature devoted to product line selection by multiproduct firms.[1] What literature does exist has focused chiefly on cost considerations: multiproduct firms are seen to emerge principally as the consequence of economies of scope in production. A recent survey of the literature on multiproduct firms (Elizabeth Bailey and Ann Friedlaender, 1982) reflects the recent literature, considering closely only the limited demand effects allowed by the "contestable markets hypothesis." Our view is that interaction between the demands for different products, and the associated strategic effects, are important determinants of the products a single firm will produce.

How is it that product lines are determined? Certainly we see several different patterns in the real world. Probably the most common pattern is that each firm produces a wide range of varieties within a product group, and a number of firms produce very similar, and sometimes virtually identical, products. Ford and General Motors produce closely competing product lines, as do Nikon, Canon, and Minolta in the camera industry, and so on.

Occasionally, however, one firm manages to gain almost exclusive control over a well-defined part of the product spectrum, and does not venture into other parts. An obvious example is Mercedes Benz in the automobile industry, and a trip through a department store will yield a number of other examples. Naturally, more complex versions of this basic pattern arise. A single firm may have several areas of control in a product group, or two or three firms may dominate one part of the product spectrum, while other firms produce less closely substitutable product lines. In addition, a fairly common historical pattern is for firms to expand the scope of their product offerings and compete more directly with each other as the market grows.

Michael Spence (1976), in a paper concerned mainly with single product firms, suggests the result that, in the multiproduct case, close substitutes will be produced by different firms. The reason is fairly straightforward: if firm A produces product 1 and product 2 is a close substitute, then production of product 2 is likely to appear more attractive to firm B than to firm A because B will not be concerned about the consequent reduction in demand for product 1.

However, one wonders, might not firm A recognize that if it doesn't produce product 2, firm B will, and therefore try to preempt B. Strategic preemption requires a two-stage (or more) decision process. In choosing to produce a particular product, firms must anticipate that this will have some effect on later competition. But surely this is precisely the way product selection occurs. As argued by Edward Prescott and Michael Visscher (1977), product selections, once decided upon, are not easily changed. Product selection is a commitment,[2] which, to a first

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[1]The two classic approaches to product selection derive from the work of Harold Hotelling (1929) and Edward Chamberlin (1933). Most of the recent work in these traditions, including the widely cited work of Kelvin Lancaster (1979), Avinash Dixit and Joseph Stiglitz (1977), Michael Spence (1976), and Steven Salop (1979) focuses on the one product per firm case.

[2]The term commitment (or "credible threat") refers to the idea that in strategic interaction, a firm (or player) might reasonably be expected to believe that a rival will only pursue actions that are in the rival's best interests. Threats that can only be carried out through suboptimal behavior (as in the Sylos-Labini limit output model) are

approximation, is taken as given in the following output or price rivalry.

In this paper we make a series of straightforward but significant points about product selection by multiproduct firms. In particular, using a very simple structure, we find that sequential decisions on product type and output can naturally give rise to equilibria in which a single firm monopolizes close substitutes. Such outcomes hold only for certain levels of demand and might, therefore, be observed only over some portion of the life cycle of the industry.

Perhaps the most closely related existing work is in the literature on preemption in product space, particularly (in addition to Prescott and Visscher) Donald Hay (1976) Curtis Eaton and Richard Lipsey (1979) and W. J. Lane (1980). Eaton and Lipsey (1979) have the idea that a foresighted monopolist would introduce a near product in a growing market before a rival. Our paper is in a similar spirit, but is concerned principally with cases in which firms have equal opportunity.

Section I sets out the basic model, Section II briefly considers monopoly, Section III derives the main results on product line rivalry, and Section IV presents a result on product line choice and entry deterrence.

I. The Model

To examine product line rivalry, we consider a constellation of four possible products. Two products are close substitutes for each other and more distant substitutes for the other pair, which are, in turn, close substitutes for each other. In particular, commodity pairs (1,2) and (3,4) are close substitutes, while pairs (1,3), (1,4), (2,3), and (2,4) are more distant substitutes. This is about the simplest structure in which the question of whether competing multiproduct firms produce close or distant substitutes can be addressed.

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not credible. This idea goes back at least as far as Thomas Schelling (1956), but has only received attention recently. Recent work includes Spence (1977, 1979), James Friedman (1979), Dixit (1980) and B. Curtis Eaton and Richard Lipsey (1979, 1980, 1981).

We use inverse demand functions and define closeness of substitutes using the cross derivatives of these functions. The price of good i is denoted p^i, the quantity of good i is denoted x^i and X is the vector (x^1, x^2, x^3, x^4). The inverse demand function is then written

$$(1) \qquad p^i = p^i(x^1, x^2, x^3, x^4) = p^i(X).$$

To focus as clearly as possible on the essential issues, we assume that the demand structure is perfectly symmetric except for the differences in substitutability already described. In saying that goods 1 and 2 are closer substitutes[3] than 1 and 3, we mean that the response of p^1 to a change in the output of good 2 is greater in absolute value than the response to a change in x^3. Since these goods are substitutes, the cross-price effects are negative, and, using subscripts to denote derivatives, we have

$$(2) \qquad p^i_j < p^i_k,$$

where i and j are close substitutes and i and k are more distant substitutes. We could imagine that the degree of substitutability might vary with X and that goods that were close substitutes in some ranges might be

[3]It is perhaps more normal to express the substitutability relationship using the ordinary demand functions $x^i(p)$, in either derivative or elasticity form. As pointed out by John Hicks (1956, pp. 156 ff.), the two definitions do not necessarily coincide, and neither definition is more "natural" than the other. Hicks referred to substitutes by our definition as "q-substitutes" and by the other definition as "p-substitutes." The (compensated) substitution effects are also sometimes referred to as "Antonelli substitution effects" and "Slutsky substitution effects," respectively, because they are elements of the Antonelli matrix and the Slutsky matrix, respectively. The Antonelli and Slutsky matrices are generalized inverses of each other. (See Angus Deaton and John Muellbauer, 1980, p. 57.) Since we are going to assume that firms use quantity rather than price as a choice variable, the q-substitute approach is more convenient. One could, however, use prices as the choice variables and use p-substitutes.

We use the derivative rather than the elasticity form for the examination of substitution effects because it is the derivative that appears directly in the mean value theorem and in the first-order conditions that are used in the analysis.

distant substitutes in others. To make the questions we wish to address well-defined without complication, (2) is assumed to hold uniformly: p_j^i evaluated anywhere in the range of interest is greater in absolute value (more negative) than p_k^i evaluated anywhere in the range of interest.

One example of a computationally simple demand structure with the properties described here arises from utility that is quadratic in X and additively separable from a numeraire good: $u = aX - X^TBX + m$, where b_{12} and b_{34} are equal and exceed other off-diagonal elements of the symmetric matrix B, which are themselves equal, and m is consumption of a numeraire good. We use this functional form in Section IV.

A firm that produces any of the four products must have made three decisions: (i) how many products to produce (the scope decision); (ii) which particular products to produce (the line decision); and (iii) which quantity to produce (or which price to charge) for each product. As logical possibilities we might imagine that these decisions could be made sequentially, or that the first, or second two, or even all three, could be made simultaneously. Which assumption is appropriate in any particular case depends on actual technological considerations. In our analysis, we treat the product line decision as strictly prior to the final price or quantity choice. In other words, firms establish prices or quantities taking their own and their rivals' line and scope decisions as given.

The final stage may, as indicated, be either a price decision or a quantity decision.[4] For concreteness, in this paper we take quantity as the third-stage decision variable. We have examined a number of our results when price is the final decision variable, and the central insights of our analysis were not affected, although there are some relatively minor differences which we mention at later points in the paper.

The overall equilibrium concept we work with for the most part is the subgame perfect equilibrium. This equilibrium concept incorporates two important ideas: first, the equilibrium is noncooperative so that at each stage equilibrium occurs when each firm is maximizing profit, given the current and previous strategy variable levels chosen by its rival, and second, each firm understands at any stage how future stages will be affected by current decisions.[5]

Our assumptions about technology are very simple. Each firm incurs a sunk cost K for each product it plans to produce at the time of the scope decision. (Indeed, it may be this sunk cost which contributes to making the scope decision credible.) A constant marginal cost c is incurred at the time quantity decisions are made. We assume K and c to be the same for all four products. Note that, while there is interaction among demands for the four commodities, we assume that their cost structures are independent: in particular, there are no economies or diseconomies of scope.

II. Monopoly

Although we are principally concerned with the rivalry between firms, there is one important insight to be established for the monopoly case. Specifically, if a monopolist chooses to produce only two products, it will choose two distant substitutes rather than two close substitutes. The reasoning involved is fairly straightforward, but it is worth being precise. Imagine that the monopolist is producing products 1 and 2, which are close substitutes, at the profit-maximizing levels. By symmetry, $x^1 = x^2 (= x)$. Holding the output level of product 1 fixed, imagine re-

[4]Whether price or quantity Nash equilibria are appropriate depends on the nature of production. Indeed, it may be useful to think of quantity and price as occurring sequentially. If a quantity decision is a credible commitment, due perhaps to practical irreversibilities in production and high storage costs, and price later clears the market, then quantity should be regarded as the third-stage decision variable. Alternatively, if a price announcement is a credible threat, with quantity being the residual variable that clears the market, the third stage should be modeled as a price game. (This interpretation is in Friedman, 1980.) For some other comments on the issue of price vs. quantity Nash equilibria, see Timothy Bresnahan (1981).

[5]The concept of subgame perfection is associated with R. Selten (1975) and has been the focus of considerable recent attention in the oligopoly literature. A good pedagogical discussion is in Martin Shubik (1982).

placing production of x^2 with an equal amount of x^3. Let $X'=(x,x,0,0)$ and let $X''=(x,0,x,0)$. The effect on the price of good 1 is as follows:

$$\Delta p^1 = p^1(X'') - p^1(X'). \tag{3}$$

Using the mean value theorem,[6] this difference can be expressed as

$$\Delta p^1 = \left(p^1_3(X^*) - p^1_2(X^*)\right)x \tag{4}$$

for some $X^* \in [X', X'']$. From (2), the price change must be positive and, by symmetry, the other price must also rise. Consequently, even without optimal readjustment of quantities, prices and profits must rise. A monopolist who plans to produce just two goods, and who is unconcerned about entry, will therefore produce two distant substitutes. This result serves as a useful base for comparison with the two-firm case.

III. Three-Stage Duopoly

A. *The Output Decision*

We now discuss the duopoly equilibrium when firms make the scope, line, and output decisions in sequence. We examine the decisions in reverse order, starting with the output decisions of firms already committed to particular line and scope decisions. The third stage is modeled as a Nash quantity (or Cournot) game, taking line and scope decisions of both firms as given. There are many possible configurations of scope and line with which firms might enter the quantity stage. Each of the four products might be produced by firm A, by firm B, by both firms, or by neither firm, giving rise to 256 possibilities. Many configurations are, however, isomorphic to one another, and many are relatively uninteresting in that they do not bear on the questions of interest, as, for example, when one firm produces all four products and the other nothing.

The most interesting situations for our analysis are those in which each firm produces two products. Firm A might produce one pair of close substitutes while firm B produced the other pair. We refer to this case as market segmentation. An alternative, market interlacing, occurs when each firm produces two less closely related products, as, for example, if firm A produces goods 1 and 3 while firm B produces goods 2 and 4. Note that segmentation or interlacing is determined in the line stage, and is taken as given when final output levels are being determined.

Consider the firms' profits in the two cases. Firm A's profit under segmentation is

$$\pi^s = p^1x^1 + p^2x^2 - c(x^1+x^2) - 2K, \tag{5}$$

where, for concreteness, firm A is assumed to produce goods 1 and 2. The superscript s denotes segmentation. The first-order condition associated with product 1 can be written

$$\pi^s_1 = MR^1 + x^2p^2_1 - c = 0, \tag{6}$$

where $MR^1 = x^1p^1_1 + p^1$, is own-marginal revenue. Second-order conditions are

$$\pi^s_{ii} < 0, \qquad i = 1,2; \tag{7}$$

$$\pi^s_{11}\pi^s_{22} - \pi^s_{12}\pi^s_{21} > 0. \tag{8}$$

The first-order condition for product 2 is similar to (6). Firm B (producing products 3 and 4) has symmetric first- and second-order conditions. Each first-order condition shows, implicitly, the profit-maximizing choice for one product, given the output levels of the others. The solution of these four reaction functions is the (noncooperative) Nash equilibrium in quantities. We assume that demand is sufficiently regular that there exists a unique equilibrium. This equilibrium must, then, be symmetric: all quantities are equal (as are all prices).We assume also that own-marginal revenue declines when the output of any other good rises:

$$MR^i_j < 0. \tag{9}$$

[6] This is the "mean value theorem for several variables" as described by, for example, Marcel Rosenlicht (1968). For a similar application of this theorem in economics, see Barbara Spencer (1979).

This is a natural condition which holds for most (but not all) plausible demand structures.

Under interlacing, firm A produces, let us say, products 1 and 3. (One can substitute i and k to achieve generality.) This leads to the first-order condition

$$(10) \qquad \pi_1^t = MR^1 + x^3 p_1^3 - c = 0,$$

and to similar second-order conditions as before. The superscript t denotes interlacing. The fundamental comparative property of segmentation and interlacing is expressed in Proposition 1.

PROPOSITION 1: *The segmented structure gives rise to higher prices and profits than the interlaced structure.*

PROOF:

By symmetry all products sell for the same price, denoted p^s under segmentation and p^t under interlacing. There are three possibilities: $p^t = p^s$, $p^t > p^s$, or $p^t < p^s$. The first two lead to contradictions. Consider first the equality case. If prices are equal, then quantities must also be equal in the two regimes, and so must MR^1. However, $p_1^2 < p_1^3$ so (6) and (10) cannot both be satisfied. Therefore p^t cannot equal p^s.

Now consider $p^t > p^s$. This implies $x^t < x^s$ and, by (9), that MR^1 is larger under interlacing. Since $p_1^2 < p_1^3 < 0$, it follows once again that (6) and (10) could not both be satisfied. Therefore $p^t < p^s$ as was to be shown.

Since $p^t < p^s$, it follows that $x^t > x^s$. Consider now total profits

$$\pi = \sum p^i x^i - c\left(\sum x^i\right) - 4K,$$

and, for concreteness, but without loss of generality, consider a change in π due to an increase in x^1:

$$\partial\pi/\partial x^1 = p^1 + \sum x^i p_1^i - c.$$

At the segmented solution $\partial\pi/\partial x^1 = x^3 p_1^3 + x^4 p_1^4 < 0$ since $MR^1 + x^2 p_1^2 - c = 0$ from (6). Similarly, $\partial\pi/\partial x^1$ is also negative at the interlaced solution using (10) rather than (6). Clearly π is decreasing in all xs, not just in x^1, between x^t and x^s. It then follows, given overall concavity of π in the x^is, that profit falls as outputs increase in moving from the segmented to the interlaced solution.

These interlaced and segmented structures are only two of many possibilities. Even confining attention to the scope structure of two products per firm, we might imagine that the same product or products could be produced by both firms, leaving one or two products unproduced. The profit of at least one firm in such cases would normally fall short of its profit even in the interlaced case, given the symmetric structure of demand. There is also a series of cases in which each product is produced by at least one firm, with some overlapping in the sense that some products are produced by both firms. We defer consideration of these and other cases for the present, and move on to consideration of the line decision.

B. *The Line Decision*

When making the line decision, firms take the scope decision of how many products to produce as fixed, and have only to decide upon which products to produce. The case for separation of the line and scope decisions is not as compelling as that for separation of line and output decisions. Nevertheless, it seems to capture an important flavor of real product selection in that firms often commit themselves to a particular market, especially to new or anticipated markets, well before actual product types are decided upon. Separation of line and scope is not crucial to the analysis in any case, but it is our feeling that the full three-stage model brings out the logical structure of the argument most clearly.

When making the product line decision, firms are aware that they will be involved in a noncooperative output game in the future and take this into account in the line stage. We examine the case in which each firm is committed, from the scope stage, to producing two products. Consider the Nash equilibrium in the game in which firms choose product lines simultaneously. For a wide range of demand structures (although not all), the Nash reaction to a rival's two products is simply the other two products. We restrict our attention first to this case, for which it follows that any 2×2 division is a Nash equilibrium, and, in particular, that market segmentation and market interlacing are equilibria.

PROPOSITION 2: *Both market segmentation and market interlacing are Nash equilibria in the simultaneous product selection game.*

The reason that both segmented and interlaced structures are observed may simply be that both are Nash equilibria at the line stage and can therefore be part of a subgame perfect equilibrium structure for the entire game. Any 2×2 division has a certain inertia associated with it. This simple insight itself seems a worthwhile addition to the Spence (1976) discussion. When the natural sequencing of product selection and output rivalry are taken into account, it is quite possible that close substitutes will be produced by a single firm.

We now consider two modifications of the model presented so far, both of which strengthen the case for segmentation. The first modification involves a change in the game being played. Specifically, the line decision process is assumed to be asymmetric: one firm is able to choose its two products first. This may occur because of random factors in the product selection process, or for some other exogenous reason. Formally the game becomes a four-stage game. As part of the subgame perfect equilibrium structure, the first firm to choose knows that its rival will act in its own best interest in the next stage. If it knows that whichever products it chooses, its rival will choose the other two,[7] then the first firm is in a position to choose either market segmentation or market interlacing as the industry structure. Since market segmentation leads to higher profits for each firm, Proposition 3 is immediate.

PROPOSITION 3: *If firms enter the line stage sequentially rather than simultaneously, market segmentation is the Nash equilibrium.*

The second modification we consider is a change in the equilibrium concept. We return to the game in which product line choices are made simultaneously, but instead of examining the Nash equilibrium, we examine a Stackelberg leader-leader equilibrium.

We define a Stackelberg strategy as one which involves taking into account the contemporaneous reaction of one's rival in setting one's own strategy.[8] In the output case, if both players follow Stackelberg strategies, the outcome is not an equilibrium because both firms choose an output other than what the other expects. However, if a firm can correctly assume that if it chooses two products, its rival will choose the other two, then a Stackelberg strategy at the line stage leads it to choose two close substitutes. The other firm, also following a Stackelberg strategy, will be doing the same thing. The joint Stackelberg equilibrium arises when the firms choose different pairs.

PROPOSITION 4: *The product line game has a joint Stackelberg equilibrium, and this equilibrium is characterized by market segmentation.*

There are two interpretations one might place on this Stackelberg equilibrium. On one hand, we can imagine that each firm literally expects the other to be a Nash follower. Firms therefore have an incorrect view of their rivals' behavior, but "by accident" select consistent actions. In equilibrium, firms are "right for the wrong reasons." This inter-

[7]This market structure is similar to the one examined by Prescott and Visscher, who considered sequential entry by firms precommitted to a single product. Here we consider sequential entry by firms precommitted to two products. Prescott and Visscher also assume that the entry and line decisions are simultaneous rather than sequential as we assume here.

[8]The term Stackelberg is sometimes used to mean that one player acts before another. Stackelberg's original model can be interpreted in either way, and usage seems to be divided. The product line game itself is an example of what is sometimes called a "game of coordination." See Shubik.

pretation then has the same appeal but also the same weakness as the traditional interpretation of the Nash equilibrium: out of equilibrium, firms' expectations about their rivals would be false.

An alternative interpretation is that firms understand the incentive structure in which they operate and recognize that other firms are much like themselves. Each firm knows that the other is trying to jockey it into selecting two closely related products. However, this coincides with each firm's own objectives and therefore leads to a consistent equilibrium in which firms are "right for the right reasons." In essence, firms accept that only Nash equilibria are individually rational and therefore cannot expect to achieve the collusive outcome. However, when there are two Nash equilibria, they can select the Nash equilibrium that strictly dominates the other for both. Each firm is a Stackelberg leader, not in the sense that it attributes false reactions to its rival, but in the sense that it correctly anticipates what the other is trying to do and is able to act on this knowledge.[9] This is the nature of the joint Stackelberg solution, and leads to a strong presumption in favor of the segmented solution, given the initial scope decision of two products each, and the assumption that the best response to any product pair selection is the other pair.

[9]At this point, some comment on terminology is perhaps appropriate. Instead of referring to this equilibrium concept as a joint Stackelberg equilibrium, one might be tempted to use the term "rational expectations" equilibrium or "consistent conjectures" equilibrium. If by rational expectations, one means that "the players know the model," then this term would be appropriate. Unfortunately the term rational expectations has been used in a number of different senses. We prefer, in microeconomics at any rate, that the term "rational expectations equilibrium" refer to a situation in which players' expectations about the levels of strategy variables chosen by rivals are confirmed in equilibrium. Thus any Nash equilibrium would be a rational expectations equilibrium. The consistent conjectures term (compare Bresnahan, Martin Perry, 1982, and Morton Kamien and Nancy Schwartz, 1983, among others) captures the idea that firms should have correct anticipations about levels of rivals' strategy variables in equilibrium and about responses of these strategy variables to change in one's own strategy variable. We prefer the term "joint Stackelberg" for our particular model.

The joint Stackelberg solution, because it coincides with a Nash equilibrium, is self-enforcing and therefore credible in earlier stages, and as a result is admissible as part of a perfect foresight structure.

As we have emphasized, Propositions 2, 3, and 4 assume that the "Nash reaction" at the line stage to a rival's product choice is the remaining two products. If rivalry at the final stage is Bertrand (Nash competition in prices), this is always so. If the final stage is, as we assume, Cournot (Nash in outputs), then the Nash response to any two products is not always the other two. For example, if products 1 and 2 are very close substitutes for each other, but virtually unrelated to products 3 and 4, then if firm A chooses products 1 and 2, firm B would choose products 1 (or 2) and 3 (or 4). In the limit, as 1 and 2 became perfect substitutes that were completely unrelated to products 3 and 4, which were perfect substitutes for each other, then firm B would have nothing to gain by producing product 3, given that it planned to produce product 4, so it would prefer to overlap firm A's product set.[10]

For such examples, our Propositions 2, 3, and 4 no longer obtain. Market segmentation is not a Nash equilibrium, while interlacing is not only the unique Nash equilibrium but the sequential entry equilibrium and joint Stackelberg equilibrium as well. Firm A, knowing that if it chooses products 1 and 2, firm B will choose 1 or 2 as well, will prefer to choose 1 and 3, to which the Nash response of firm B is product 2 and 4: interlacing emerges.

What is required to preclude such examples? The Nash response to a product pair is always the other pair as long as the "close" products are reasonably differentiated from each other, and not too strongly differentiated from the other pair. For example, using the quadratic utility function introduced in Section II, if $a=5$, $b_{ii}=1$ $(i=1,2,3,4)$ and $b_{12}=b_{34}=.4$, the best response to a choice of products 1 and 2 would be 3 and 4 as long as the elements $b_{13}=b_{14}=b_{23}=b_{24}$ exceed .05.

[10]We are grateful to Simon Anderson for pointing out this example to us.

C. *The Scope Decision*

Why should the firms settle on two products each? Consider the Nash reaction functions for the scope decision. Demand may be sufficiently low that if one firm commits to only one product, the other firm would prefer not to enter at all. On the other hand, demand may be so great that even if one firm committed itself to all four products, the optimal response of its rival would be to produce all four products also: complete overlapping.[11] Only if demand is in that intermediate range where the optimal response to a scope decision of two is also two can the equilibrium structure described in the previous subsection emerge.

A subgame perfect equilibrium is a Nash equilibrium in the overall (three-stage) game that is also a Nash equilibrium in any subgame; that is, in the two-stage game of product line and output choices and in the one-stage game of output choice alone. Therefore, the point remains that there are ranges of demand for which market segmentation is a subgame perfect equilibrium. Similarly, the subgame perfect equilibrium for the four-stage game involving sequential entry in the line stage is characterized by market segmentation for some demand levels, as is the equilibrium incorporating a joint Stackelberg solution in the product line stage. However, as growth occurred in the market and the game were repeated, market segmentation would be replaced by market overlapping.

We have presented a simple model which we believe throws some light on product line rivalry between firms. We find that market segmentation is a very reasonable outcome once the multistage structure of market rivalry is explicitly recognized, although many other configurations are possible, including overlapping of firms. In the next section we discuss how the threat of further entry can increase the likelihood that interlacing rather than segmentation is the outcome.

[11]This last result depends upon our assumption that competition at the final stage is a Nash game in outputs (a Cournot-Nash game). Were it a Nash game in prices (a Bertrand-Nash game), then no more than one firm would ever produce the same product.

IV. Competition as Entry Deterrence

Our analysis thus far has assumed that at the time firms make their line decisions, there is no possibility of further entry. Relaxing this assumption increases the likelihood that the outcome of sequential product line choice or a joint Stackelberg equilibrium is one of market interlacing: firms that have already entered and made a scope decision may deliberately choose an interlaced structure to make the market more competitive, reducing the profitability of further entry.

Consider again the constellation of four products of equation (1) and the product line decisions of two firms, A and B, each having a scope of two products. Propositions 3 and 4 established the presumption in favor of segmentation in the absence of a threat of entry. Assume, however, that further entry is possible after firms A and B have made their line decisions. Consider, for simplicity, the case of a single firm entering and establishing production of just one of the four products. Because of the symmetry of our specification, it does not matter which one, so assume that it is product 1. If firm A has committed itself to products 1 and 2 and firm B to products 3 and 4 (the segmented case), then the profits of the three firms will be given by

$$(11) \quad \pi^{ASE} = p^1(X)x_A^1 + p^2(X)x^2 - c(x_A^1 + x^2) - 2K,$$

$$(12) \quad \pi^{BSE} = p^3(X)x^3 + p^4(X)x^4 - c(x^3 + x^4) - 2K,$$

$$(13) \quad \pi^{ESE} = p^1(X)x_E^1 - cx_E^1 - K,$$

where

$$(14) \quad X = (x_A^1 + x_E^1, x^2, x^3, x^4),$$

and the outputs are at their Cournot equilibrium values. Here x_A^1 denotes the output of commodity 1 produced by firm A and x_E^1

that produced by the entrant; π^{ASE}, π^{BSE}, and π^{ESE} denote equilibrium profits of firm A, firm B, and the entrant, respectively, under market segmentation with entry.

Under market interlacing, with firm A committed to producing products 1 and 3 and firm B to 2 and 4, after-entry profits will be given by

$$(15)\quad \pi^{AIE} = p^1(X)x_A^1 + p^3(X)x^3 - c(x_A^1 + x^3) - 2K,$$

$$(16)\quad \pi^{BIE} = p^2(X)x^2 + p^4(X)x^4 - c(x^2 + x^4) - 2K,$$

$$(17)\quad \pi^{EIE} = p^1(X)x_E^1 - cx_E^1 - K,$$

where now π^{AIE}, π^{BIE}, and π^{EIE} denote the equilibrium levels of the three firms' profits when product lines are interlaced. The value X continues to be defined by (14), and the outputs assume their Cournot values under interlacing.

Finally, under market interlacing without entry, firms A and B will earn π^{AI} and π^{BI} given by

$$(18)\quad \pi^{AI} = p^1(X)x^1 + p^3(X)x^3 - c(x^1 + x^3) - 2K,$$

$$(19)\quad \pi^{BI} = p^2(X)x^2 + p^4(X)x^4 - c(x^2 + x^4) - 2K,$$

$$(20)\quad X = (x^1, x^2, x^3, x^4).$$

We now state:

PROPOSITION 5: *With the threat of further entry, the interlaced structure can give rise to higher prices and profits for both incumbents than the segmented structure.*

PROOF:

This results obtains if: 1) under segmentation entry is profitable ($\pi^{ESE} > 0$), 2) under interlacing it is not ($\pi^{EIE} < 0$), and 3) firms A and B earn higher profits with an interlaced structure and no entry than with a segmented structure with entry ($\pi^{AI} > \pi^{ASE}$ and $\pi^{BI} > \pi^{BSE}$). To establish that these three conditions can be satisfied simultaneously, we present an example using the linear demand structure mentioned in Section I: $u = aX - X^TBX + m$. (The calculations are long and tedious, and were done on a computer.) When $b_{ii} = 1$, $i = 1,2,3,4$; $b_{12} = b_{34} = .3$ $b_{13} = b_{14} = b_{23} = b_{24} = .1$, $a = 5$, $c = 2$, and $K = .4$, we obtain, under segmentation with entry: $P = (2.93, 3.26, 3.37, 3.37)$; $\pi^{ASE} = 0.16$; $\pi^{BSE} = 0.64$; $\pi^{ESE} = 0.03$. Under interlacing with entry: $P = (2.85, 3.20, 3.23, 3.25)$; $\pi^{AIE} = 0.23$; $\pi^{BIE} = 0.56$; $\pi^{EIE} = -0.04$. Finally, under interlacing without entry: $P = (3.27, 3.27, 3.27, 3.27)$; $\pi^{AI} = 0.66$; $\pi^{BI} = 0.66$.

At these values, market segmentation permits entry while interlacing does not. The initial two entrants earn higher profits under interlacing without entry than under a segmented structure with entry.

Perhaps it is not surprising that firm A earns a higher profit under interlacing without entry than under segmentation with entry, since it is the firm that ends up sharing a product with the entrant. More surprising is that even firm B can earn a higher profit under the first configuration than under the second.

What conditions are likely to lead to market interlacing as entry deterrence? One is that the degree of substitutability between the two pairs of "close" products substantially exceed that between other pairs. Otherwise the attractiveness of entry by a third firm is unlikely to be affected by the first two firms' decision to interlace or segment. If entry is unprofitable under either configuration, segmentation is the perferred equilibrium structure for firms A and B.

As long as both firms A and B experience lower profits under interlacing without entry than under segmentation with entry, and as long as interlacing does effectively deter entry, then interlacing will emerge as the sequential entry equilibrium and the joint Stackelberg equilibrium. There are, of course, cases in which entry-deterring interlacing would be preferred by firm A but not by firm B, provided both firms knew that one of firm A's products would be the target for the entrant. However, as suggested by the doctrine of insufficient reason, firms A and B might reasonably regard their products as equally likely targets for a later entrant. This reinforces the symmetric preference for interlacing. Furthermore, any risk aversion on the part of firms A and B will tend to make interlacing more likely as a sequential entry equilibrium or a joint Stackelberg equilibrium.

It is important to note that we are considering situations in which a third firm commits itself to entry after firms A and B have made their product line decisions. If the entrant had committed itself beforehand, a threat by firms A and B to interlace is not credible. The solution will, in our example, again be one of segmentation.

V. Concluding Remarks

This paper has focused on the (in our view) much neglected subject of product line selection by multiproduct firms. We have restricted attention to "demand-side" influences on product selection. It is fairly clear that "cost-side" considerations are also very important. In this paper, products are independent on the cost side, but if there were, for example, economies of scope between particular products, there would clearly be a stronger incentive for one firm to produce these products. Oil refineries produce a spectrum of different fuels, from heavy oil to light fuels like kerosene, because they are all byproducts of each other: a fairly strong form of economies of scope.

There is a substantial recent literature on economies of scope and multiproduct firms culminating in the 1982 book by William Baumol, John Panzar, and Robert Willig (B-P-W). One other important difference between their work and the present paper, aside from the role of the cost side in the analysis, is the assumption concerning the expectations of firms. In B-P-W, before a firm enters, it takes the current price of each product as given; it is as if scope, line, and price decisions were all made simultaneously. Not surprisingly, this assumption yields an outcome with some resemblance to perfect competition. Our assumption is rather different: firms understand, before anything is actually produced, how the noncooperative output game will work out.

Our basic message is that recognizing the sequential nature of decision making is important in understanding product line rivalry. Market segmentation, in which each firm controls a certain part of the product spectrum, is an equilibrium outcome, although it will only be observed over some fraction of the life cycle of the industry. An interesting extension suggests itself if we consider the possibility of further entry beyond the first two firms in an industry. An interlaced structure, in which close substitutes are produced by different firms, is a more competitive structure than segmentation. More to the point, it is a commitment to greater competition from the point of view of an additional potential entrant. The entrant might therefore be deterred from entry in an interlaced market when it would enter a segmented market: competition as entry deterrence.

Our results have implications for the research and development activity of firms that is aimed at introducing new products. Our theory suggests that a firm that is guaranteed a monopoly over a range of potential products will (provided that demand is uniform) seek to develop those products that are most distant substitutes for what it is currently producing. Production of these products will reduce demand for the monopolist's current products least. When production of a range of potential products is limited to a group of competing firms that are established in the market, each firm is likely to seek to develop products that are close substitutes for what it currently produces, since joint production of these products will lead to less intense price and output competition at a later stage. Finally, if there is threat of entry by firms currently outside the market, each firm may seek to develop products that are more distant substitutes *because* the consequent competition may be so intense as to deter entry.

The analysis of this paper is based on a rather specific formulation, and therefore the results should be interpreted with caution. Generalization to more complex product sets and cost structures would complicate the analysis considerably. Nevertheless, we feel that the extended example developed here identifies central economic tendencies which would continue to operate in more general settings.

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