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## Credible Spatial Preemption

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Discussion Paper No. 577  
CREDIBLE SPATIAL PREEMPTION\*

by  
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## Credible Spatial Preemption

### 1. Introduction

Several previous studies have argued that incumbent firms, when faced with potential entry into competing goods, may be able to deter such entry by differentiated competitors by producing the differentiated good itself. We shall see here that a crucial parameter governing the likelihood of successful preemption is the level of exit costs, and is as important as sunk entry costs. The conclusions of earlier studies, such as Schmalensee (1978) and Eaton and Lipsey (1979), implicitly assumed infinite exit costs. We show that these conclusions are substantially altered when one allows multiproduct incumbent firms to exit in response to entry. Since exit costs (e.g., severance pay and demolition costs) are often low, this analysis reduces the likelihood that spatial preemption is an important barrier to entry.

The basic result is illustrated by the following tale. Suppose that there are two goods, apples and oranges, both of which are produced at constant marginal cost after a fixed set-up cost is borne. Also assume that competition is in prices. If one firm produced both goods, then it would appear that rational entry could not occur: if another firm entered apples, the post-entry price competition in apples would drive prices to marginal cost and imply zero post-entry apple profits for the entrant, making costly entry unprofitable. Given that entry would appear irrational, an incumbent orange firm may believe that by introducing apples, it could deter entry into the fruit industry. This is the basic argument of earlier analyses: by ensuring intensive post-entry competition, the incumbent may deter entry and even extend its market power to close substitutes if the diseconomies of scope were not severe.

However, in the case of a differentiated product market, we demonstrate that it may not be credible for a multiproduct incumbent to threaten an entrant with intense post-entry competition. In our example, suppose entry into apples did occur. As long as both the incumbent and entrant stayed in the apple market, the apple price would be equal to marginal and average cost, and apple profits would be zero. However, while this apple price war continues, demand for any substitute, e.g., oranges, will be depressed. Continuing the price war would mean no apple profits and small orange profits for the multiproduct firm. While the price war would also yield no profits for the entrant, their positions are not symmetric. The entrant has no reason to exit since exit would also yield no profits and possibly be costly. Hence, once in, it is credible for the entrant to threaten to stay. Given the entrant's immovability, the only rational response on the part of the incumbent is to leave the apple market if exit costs are not prohibitive since the resulting differentiated duopoly will result in a higher apple price, higher demand for oranges, and higher profits for the incumbent firm even though it will produce only oranges. Knowing this about the post-entry game, a firm will enter if the entry costs are covered by the rents that accrue to a differentiated duopolist. Since the relevant post-entry benchmark is differentiated duopoly instead of head-to-head undifferentiated competition with the incumbent, entry is much more likely than previous analyses indicate. In particular, crowding the product spectrum will not credibly deter entry unless an incumbents's exit costs are high.

We develop these points in this paper. First, we analyze an extension of the Prescott-Visscher (1977) analysis of foresighted entry where exit is allowed. Second, we explore the implications of these results for crowding arguments as developed, for example, by Schmalensee (1978). Next, we examine

a real time model of entry and compare the outcome to that predicted by Eaton and Lipsey (1979). Fourth, we examine the implications this analysis has for equilibrium relationships among product lines: do firms specialize in particular niches, resulting in market segmentation, or will all firms produce all types of goods, resulting in an interlaced market structure?

## 2. An Example of Deterred Entry

Before we move to the two-good example, first let us examine a case where entry into a monopolized market is deterred due to credible threats of intense post-entry competition. Suppose that all firms have access to the technology - a fixed entry cost of  $F > 0$  and a constant marginal cost of  $c > 0$ . Suppose there is currently a monopoly. If post-entry competition would be in price, then post-entry profits for both incumbent and entrant would be zero since the Bertrand equilibrium would be marginal cost pricing. Since post-entry profits are nonnegative, neither firm would have any incentive to leave and both would definitely stay if there were the slightest exit costs. Entry would therefore be irrational since post-entry profits could not cover the fixed entry cost.

In this example, the intense post-entry competition makes entry unprofitable and an incumbent monopolist is secure. If the post-entry competition is not as intense, such as with Cournot quantity competition, the entrant will earn duopoly rents which may cover the entry costs. From this example one may be lead to believe that as the post-entry competition is more intense, the likelihood of successful entry declines. The purpose of studying this example here is two-fold. First, some of the subgames which we must solve below will be this game. Second, it will be contrasted with our analysis of a multiproduct market where intense post-entry competition makes entry easier.

### 3. The Basic Model

The basic points can be made in a two good model. We also assume that there are two firms which could potentially produce these goods--it will be clear that this is often inessential. Since the nature of competition--Bertrand or Cournot--is not essential, we will not so confine the analysis. The crucial elements are the distribution and level of profits under various market structures and the level of entry and exit costs. To this end we define the following notation:

$\pi_M^A$ ( $\pi_M^O$ )	profits when only apples (oranges) are produced and produced by one firm
$\pi_M^{AO}$	total profits to a monopolist producing both apples and oranges;
$\pi_D^A$ ( $\pi_D^O$ )	profits to the apple (orange) producer when two competing firms produce different goods--a differentiated duopoly;
$\pi_{A00}^A$ ( $\pi_{A00}^O$ )	profits on apple (orange) sales for an apple (orange) producer when both goods are produced, apples are produced by only one firm, but there is competition in oranges;
$\pi_{AAO}^A$ ( $\pi_{AAO}^O$ )	similarly when competition exists only in apples;
$\pi_{A00}^{AO}$ ( $\pi_{AAO}^{AO}$ )	total profits to multiproduct firm when it faces competition in oranges (apples) only;
$\pi_{CAO}^A$ ( $\pi_{CAO}^O$ )	apple (orange) profits per firm when there is competition in both goods;
$\pi_{AA}^A$ ( $\pi_{OO}^O$ )	a firm's profits on apple (orange) sales when there are two apple (orange) firms and no orange (apple) firms;
$F_E^i$ ( $F_X^i$ )	the nonnegative fixed cost of entering (exiting) production of good $i$ , $i = A, O$ .

There are several reasonable assumptions to make concerning relations among these profit flows. A first set of assumptions are obvious.

$$(A1) \quad \pi_M^{A0} > \pi_M^A, \pi_M^0, \pi_D^A + \pi_D^0 > 0$$

$$(A2) \quad \pi_D^A > \pi_{AA0}^A \geq 0 \quad (\pi_D^0 > \pi_{A00}^0 \geq 0)$$

$$(A3) \quad \pi_{A00}^A > \pi_{CA0}^A \geq 0 \quad (\pi_{AA0}^0 > \pi_{CA0}^0 \geq 0)$$

These assumptions just state that competition generally reduces profits. They are all satisfied if either price or quantity is the strategic variable. We assume everywhere that gross profits are always nonnegative. This holds as long as post-entry economies of scale are not so severe that competition forces profits negative. This assumption is reasonable and necessary if we are to avoid inessential complications.

We will also want to assume that the goods are competing goods, that is, substitutes. This is modelled by some more restrictions.

$$(A4) \quad \pi_D^A > \pi_{A00}^{A0} > 0 \quad (\pi_D^0 > \pi_{AA0}^{A0} > 0)$$

$$(A5) \quad F_E^0 > \pi_{A00}^0 \quad (F_E^A > \pi_{AA0}^A)$$

$$(A6) \quad \pi_{AA0}^{A0} > \pi_{AA}^A \geq \pi_{A00}^A \geq 0 \quad (\pi_{A00}^{A0} > \pi_{00}^0 \geq \pi_{A00}^0 \geq 0)$$

$$(A7) \quad \pi_M^A + \pi_M^0 > \pi_M^{A0} > 0$$

$$(A8) \quad \pi_D^A - F_E^A > \pi_D^O - F_E^O \quad \text{and} \quad \pi_M^A - F_E^A > \pi_M^O - F_E^O, 0.$$

(A4) is the crucial assumption for the purposes of this essay. It states that a firm prefers to be the sole producer of one good than to produce both when a competitor is already producing the other good. It is more likely to be satisfied as the two goods are closer substitutes and as head-to-head competition is more intense. For example, it always holds if competition is in prices, variable costs are proportional to output, and the goods are substitutes. Also, (A5) asserts that entry costs are sufficiently high that it doesn't pay to enter a market if the entrant will not have a monopoly on the good. We make this assumption in order to focus on preemption issues and it is not essential for any result. (A6) and (A7) are simply relations implied by substitutability of apples and oranges. Since one good is likely to be more profitable, (A8) chooses apples to be the more profitable good.

#### 4. Sequential Entry Equilibrium

In this section we will examine a sequential entry model similar to that in Prescott and Visscher (1977). They make the (often expressed) argument that one needs to restrict the number of products that a firm may produce in order to avoid a monopoly outcome. We will show that when exit is allowed the first entrant may not be able to deter entry by the second entrant by filling the product spectrum. In such cases, one will have a multifirm equilibrium without economies of scope.

The game we will examine is a four stage game. In the first stage, player one enters the apple, orange, or both markets, paying the corresponding fixed costs of entry. In the second stage, firm two makes its entry decisions and investments. In the third stage, both firms simultaneously make exit decisions. At the end of the third stage, the market structure is in place.



In the fourth stage, the two firms engage in the duopolistic competition the outcome of which is given by the appropriate  $\pi$  defined above. At each stage, players know the decisions made in earlier stages.

Note that this game is identical to the Prescott-Visscher game except that the latter did not have the exit stage. Implicitly, entry is irreversible in their model. However, irreversibility of investment is distinct from the sunken nature of entry costs. We also assume that entry costs are sunk, but we allow firms to exit in the face of competition. The addition of this exit stage adds an important element of realism and avoids equating the sunken nature of investment costs with a commitment to be active in a market.

To solve for the equilibrium, we solve each subgame, starting with the last. The fourth stage outcomes are summarized in the  $\pi$ 's defined above. The possible third stage games are numerous, being distinguished by the market structures in existence at the beginning of the third stage. Many of these subgames have obvious solutions. For example, if one firm has entered apples only and the other firm has entered only oranges, there will be no exits, since an exit decision would lead to no profits, but staying would lead to positive profits by (A2).

The more interesting situations arise when both firms have entered a common market. Suppose that firm one has entered apples and oranges and firm two has entered apples. The third stage payoff matrix is then:

Firm 1	Firm 2	
	Exit A	Stay in A
Exit A	$\pi_M^O - F_X^A, -F_X^A$	$\pi_D^O - F_X^A, \pi_D^A$
Stay in both	$\pi_M^{AO}, -F_X^A$	$\pi_{AAO}^{AO}, \pi_{AAO}^A$
Exit O	$\pi_M^A - F_X^O, -F_X^A$	$\pi_{AA}^A - F_X^O, \pi_{AA}^A$
Exit both	$-F_X^A - F_X^O, -F_X^A$	$-F_X^A - F_X^O, \pi_M^A$

Since both exit costs and profits from participation are nonnegative, staying in apples is a (possibly weakly) dominant strategy for firm two. Hence, the unique perfect equilibrium has two staying in apples and one making the best response. If exit costs are high, then firm one will also stay in both markets. Firm one will certainly not exit oranges since (A6) implies that staying in both dominates exiting oranges. If exit costs are low, firm one may leave apples since (A4) implies that a local orange monopoly is preferred to fighting over apples. The issue of exiting apples is settled by comparing duopoly orange profits net of exit costs to profits from selling both apples and oranges, facing competition in apples. Firm one exits if and only if  $\pi_D^O - F_X^A > \pi_{AAO}^{AO}$ . This is likely to be true if exit costs are low and head-to-head competition in apples results in low apple prices, low apple profits and low orange demand. For example, if variable costs are proportional to output and price were the strategic variable, then  $\pi_{AA}^A = \pi_{AAO}^A = 0$ . As long

as  $F_X^A$  is small,  $\pi_D^O - F_X^A > \pi_{AAO}^{AO}$  and firm one exits apples.

The case of firm one being in both markets and firm two being in oranges is completely analogous. Also, it is clear that switching the roles of firms one and two will not cause any substantive changes in the equilibria of the third stage games.

The last case is when both firms are in both markets. The payoff matrix for that stage three subgame is

Firm One	Firm two			
	Stay in Both	Exit A	Exit O	Exit both
Stay in both	$\pi_{CAO}^{AO}, \pi_{CAO}^{AO}$	$\pi_{AOO}^{AO}, \pi_{AOO}^O - F_X^A$	$\pi_{AOO}^{AO}, \pi_{AOO}^A - F_X^O$	$\pi_M^{AO}, -F_X^A - F_X^O$
Exit A	$\pi_{AOO}^O - F_X^A, \pi_{AOO}^{AO}$	$\pi_{OO}^O - F_X^A, \pi_{OO}^O - F_X^A$	$\pi_D^O - F_X^A, \pi_D^A - F_X^O$	$\pi_M^O - F_X^A, -F_X^A - F_X^O$
Exit O	$\pi_{AAO}^A - F_X^O, \pi_{AAO}^{AO}$	$\pi_D^A - F_X^O, \pi_D^O - F_X^A$	$\pi_{AA}^A - F_X^O, \pi_{AA}^A - F_X^O$	$\pi_M^A - F_X^O, -F_X^A - F_X^O$
Exit both	$-F_X^A - F_X^O, \pi_M^{AO}$	$-F_X^A - F_X^O, \pi_M^O - F_X^A$	$-F_X^A - F_X^O, \pi_M^A - F_X^O$	$-F_X^A - F_X^O, -F_X^A - F_X^O$

First note that "staying in both" dominates "exit both" for both players, allowing us to drop any consideration of that strategy. If exit costs are low, two equilibria are where one firm exits apples and the other exits oranges. Because of the symmetric market structure and the undesirability of head-to-head competition, another (and Pareto inferior) equilibrium is for both to randomize over which product to leave, i.e., firm one leaves apples or oranges with equal probability and similarly for firm two. An even worse

possibility would be for both to stay in both markets, that outcome being an equilibrium if head-to-head competition is extreme, for example, if  $\pi_{CAO}^{AO} = \pi_{AAO}^A = \pi_{AA}^A = \pi_{OO}^O = \pi_{A00}^O = 0$ . While there may be many equilibria, it is clear that if fixed costs are low, the only Pareto efficient equilibria are for the firms to leave different markets. If exit costs were high, then exit is less likely and the final market structure would more likely be intensely competitive. In either case, the key fact is that firms will not find it advantageous to bring about this market structure since it would either immediately leave one of the markets it had just entered, or stay and face head-to-head competition in one of the goods, in which case the entry costs exceed the marginal revenue, by (A5) and (A6).

The second stage game is not as complex since firm two is faced with only four possible situations. If firm one did not enter any market, then firm two is effectively a monopolist, entering both markets or just apples, whichever leads to greater net profits. If firm one is in only apples or only oranges, then firm two enters the other market if entry costs are not prohibitive. For example, suppose firm enters apples in stage one. Since firm one will not exit apples under any condition in stage three, if firm two were to enter both markets in stage two, it would either leave apples in stage three or stay and realize marginal revenue which would be less than the entry costs by (A5) and (A6), and if it entered only apples in stage two, it would either leave in stage two or stay and suffer low profits. Therefore, if firm one is in apples, then firm two will enter oranges if  $\pi_D^O > F_E^O$  and otherwise do nothing. Similarly, if firm one is in oranges, firm two would enter only apples and only if  $\pi_D^A > F_E^A$ .

The most complex case is if firm one has entered both markets. If firm two enters either oranges or apples in stage two, then in stage three firm one

will leave the other market if exit costs are low. If firm two enters both, then the best it could hope for in stage three is that the firms leave opposite markets. A differentiated duopoly at best results in either case and by entering both markets firm two bears  $F_E^A$  and  $F_E^O$ . Hence, if it sees firm one in both markets in stage two, firm two will enter either apples or oranges, choosing that one with greater duopoly profits net of entry costs and only if it knows that firm one will exit when faced with direct competition.

Finally, we may solve for the stage one choice of firm one. If exit costs are low, firm one knows that if it enters both markets, it will eventually exit one of them. Hence, it should choose to enter that market which will result in greater net profits. If exit costs are so high that entry comprises a credible threat to stay, then it will enter both markets. In summary, we have shown that the unique equilibrium is:

- i. firm one enters apples and firm two enters oranges if

$$\pi_D^A - F_E^A > \pi_D^O - F_E^O > 0$$

$$\text{and either } \pi_D^O > \pi_{AO}^{AO} + F_X^A \text{ or } \pi_D^A > \pi_{AO}^{AO} + F_X^O ;$$

- ii. only firm one enters and it enters only apples if

$$\pi_D^O - F_E^O < 0,$$

$$\text{and either } \pi_M^A - F_E^A > \pi_M^{AO} - F_E^A - F_E^O \text{ or } \pi_D^O > \pi_{AAO}^{AO} + F_X^A ;$$

iii. firm one enters both apples and oranges if

$$\pi_M^{AO} - F_E^O - F_E^A > \pi_M^A - F_E^A, \pi_M^O - F_E^O,$$

$$\text{and either } \pi_D^A - F_E^A < 0 \text{ or } \pi_{AAO}^{AO} > F_X^A,$$

$$\text{and either } \pi_D^O - F_E^O < 0 \text{ or } \pi_{AOO}^{AO} > \pi_D^A - F_X^O.$$

In (i) the first firm enters the more profitable market, apples, and the second firm enters the other market. This occurs when duopoly rents cover entry costs and a two-good monopoly is vulnerable to entry. In (ii) firm one enters apples and firm two stays out of the industry. This happens when oranges are not sufficiently profitable to attract an entrant when they compete with apples and either an apple monopoly is better than an apple-orange monopoly or firm one holds back from offering both because doing so would open it up to entry in the more profitable apple market. Note that in this case the threat of entry may result in a Pareto inferior outcome since firm one wants to produce oranges but will not because of the threat. In (iii) the first firm produces both goods with no fear of firm two entering either good. This occurs because for both goods either duopoly profits do not cover entry costs or exit costs are so large that the first firm will not leave a product even when confronting a perfect substitute.

At this point we should compare our analysis to that of Schmalansee (1978). He argued that an incumbent firm would preempt entry by brand proliferation, that is, introduce several similar products, leaving no profitable niche for any entrant. He assumes that no brands would be withdrawn in response to entry. It is clear that even if entry occurred only

between existing brands (as Schmalansee assumes) that the foregoing arguments would imply that a multiproduct incumbent may want to withdraw nearby goods. For example, suppose the products were modelled by a circle and the incumbent had products at each "hour", i.e., at noon, 1 o'clock, 2 o'clock, etc. Also assume that entry at any point is unprofitable if the incumbent stands fast. According to Schmalansee, entry is thereby preempted. However, suppose entry did occur at 12:30. Since 1:00 and 12:00 are good substitutes for 12:30, the competition between the 12:30 good and the 12:00 and 1:00 goods will drive equilibrium profits and prices down for all three goods. 12:30 will charge a low price out of fear of being undercut by 12:00 and/or 1:00. The multiproduct firm will have to choose between lower prices on the 12:00 and 1:00 goods, which would cause loss of sales of the 11:00 and 2:00 goods, or keep prices high and see sales of 12:00 and 1:00 fall substantially. This dilemma is more intense as the existing goods are more crowded, increasing the likelihood that the entrant will undercut and compete with more goods than just its immediate neighbors. Therefore, if exit costs are low and the local competition is intense, the multiproduct firm will possibly withdraw goods close to the entrant. That would give the entrant incentive to raise its price since, with 12:00 and 1:00 gone, it will have a larger number of inframarginal customers to exploit relative to marginal customers that it is competing for with the multiproduct firm.

In any case, if entering between existing goods is not successful at forcing the incumbent to withdraw, a direct attack may be successful. Again, assume that variable costs are proportional to output and that competition is in prices. If an entrant enters at 12:00, then price for that good will drop to marginal cost and neither firm is making money on sales of 12:00. If the 1:00 and 11:00 goods are close enough that their sales are affected in the

sense that their sales would increase if the 12:00 price increased above marginal cost, then we would have a situation comparable to the simpler example studied above: the entrant has no incentive to leave the 12:00 good since it is not losing money, and the incumbent will therefore withdraw its 12:00 good since it is not yielding any profits and exit will cause the 12:00 price to rise, helping to improve profits from 11:00 and 1:00. In this case, entry at 12:00 will be successful and should be undertaken if profits after the incumbent withdraws cover the fixed entry costs. In fact, it is clear that successful entry is more likely as the incumbent initially crowds the product of space more, showing that brand proliferation may make successful entry more likely.

The basic lesson from the foregoing is that one cannot preempt entry by introducing many goods unless the exit costs are substantial. A direct attack on a firm's position may be successful if that firm has related products which would lose sales if it insisted on fighting the entrant. This direct attack is more likely to be successful as the post-entry game is more intensely competitive.

##### 5. Entry in a Growing Market

The preceding was a highly stylized model of entry and exit and certain crucial features were not well-motivated. In particular we chose to make entry decisions sequential and exit decisions simultaneous. In this section we study a real time model of entry which justifies that choice and allows us to study the dynamic evolution of market structure.

In this section, we want to model growing demand for goods in the industry. Therefore, let  $\pi_M^A$ ,  $\pi_M^{AO}$ ,  $\pi_D^A$ ,  $\pi_D^O$ ,  $\pi_{AOO}^A$  and  $\pi_{AAO}^O$  of the preceding sections represent profit flows and be increasing functions of time, with our assumptions (A1)-(A7) holding at each time  $t$ . Also, we assume that profits



are initially so low and increasing so slowly that no one will want to bear the entry costs and enter immediately. On the other hand, we assume that the game lasts long enough that the market becomes arbitrarily large. Again, we assume that there are two firms, each facing the same cost of capital,  $r$ , and maximizing the present value of its net cash flow. We want to maintain the assumption that apples are more profitable than oranges. The following condition, assumed to hold at all times  $t$ , is sufficient though clearly not necessary:

$$(A8') \quad \pi_D^A - rF_E^A > \pi_D^O - rF_E^O, \quad \pi_M^A - rF_E^A > \pi_M^O - rF_E^O, \quad \text{and } F_E^A = F_E^O.$$

To avoid unenlightening technicalities we will further assume that competition is in prices and that variable costs are proportional to output. Therefore, if there are ever two firms producing a good, that good will be priced at marginal cost and profits on sales of that good will be zero. Specifically,  $\pi_{AA}^A = \pi_{OO}^O = \pi_{AAO}^A = \pi_{AOO}^O = 0$ .

If exit costs are high, we have results similar to Eaton and Lipsey (1979): an incumbent apple monopolist would enter oranges just before an entrant could profitably enter oranges<sup>1</sup>. Once in oranges, the apple incumbent preempts any entry in either good since high fixed costs make credible his threat to stay in each good forever, and the intense post-entry competition makes entry unprofitable. (Eaton and Lipsey discuss this in the context of a continuum of goods but it is clear that for these points, the exact nature of the product spectrum is not essential.) This does not imply that the ultimate monopolist makes more money because of his ability to preempt entry. Since only one firm will enter the industry in equilibrium, that firm will enter so

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<sup>1</sup>In Eaton and Lipsey (1980 and 1981) the role of high exit costs as a deterrent to entry is examined in a homogeneous good market.

early that its net present value will be zero. It must do so because to wait will just give opportunity to the other firm to enter at a profitable time which it surely will since the alternative is to be shut out of the industry.

To focus on the opposite case of small exit costs, we assume that  $F_X^A$  and  $F_X^O$  are positive but trivially small. In particular, assume

$$(A9) \quad rF_X^A < \pi_D^O - \pi_{AAO}^{AO} \quad \text{and} \quad rF_X^O < \pi_D^A - \pi_{A00}^{AO}$$

We allow each firm to choose to enter any market once and to exit, such entry and exit coming at any time. We make this restriction on entry to reduce the number of subgames we need to examine and avoid annoying problems of multiple entry and exit. It will be plausible that this is not a substantive restriction, particularly since it rules out only Pareto inferior possibilities for the strategically active players.

As always, the nature and duration of time is important. We want to avoid the problems of multiplicity which infinite horizon and continuous time bring. Hence, even though the manipulations will appear to be in continuous unbounded time, think of time as being infinitesimally discrete and ending at some distant future time,  $T$ . Also, assume that the firms alternate, with one firm moving at "odd" moments and the other firm moving at "even" moments. This allows the games to be solved in a recursive fashion. However, we present intuitive arguments below instead of the tedious recursive calculations.

As before, we will build the solution to the game from later stages to earlier stages. First, suppose that the incumbent firm produces only apples, the more profitable good. Since demand grows without bound, at same time,  $\tau_D^A$ , the opportunity cost of the capital necessary to enter oranges,  $rF_E^O$ , will equal the duopoly profit flow that would come with

entry,  $\pi_D^0(\tau_D^A)$ . At such a point, the entrant would surely enter since profits increase thereafter. The entrant would never want to leave oranges in the future since the positive exit costs and nonnegative profits make, according to our previous arguments, any predatory retaliation by the incumbent irrational. Let  $\Pi_2$  be the present value of net profits for the entrant when he enters oranges at  $\tau_D^A$  and enjoys differentiated competition with apples thereafter.

One might think that the entrant may be able to enter apples and push the incumbent to oranges. This case is not covered by our previous analysis since we did not have a second round of entry decisions in our previous game. However, we should note that the symmetric subgame where both produce only apples is essentially a war of attrition, e.g., see Milgrom and Weber (1981). The essential fact about a war of attrition of use to us is that the unique symmetric equilibrium would be for both to choose a random date at which it would exit, both dates being drawn from the same distribution. In such a mixed strategy equilibrium, expected profits for the entrant would at most be equal to the profits it would obtain by immediately leaving apples and then wait for the appropriate time to introduce oranges. Hence, if the symmetric equilibrium would result after the entrant entered apples, it would be unwise for it to enter apples in the first place. Of course, there are multiple equilibria to this war of attrition. For our purposes, concentrating on the symmetric war of attrition equilibrium is appropriate since we are assuming identical firms. Therefore, when faced with a single-product firm producing apples, the entrant will wait until  $\tau_D^A$  to enter oranges.

Second, suppose that the incumbent was producing both apples and oranges. We saw above that under certain conditions the incumbent would leave apples, the most profitable good, and be content with  $\pi_D^0$  thereafter. First,

it is clear that the incumbent will at any time leave apples if confronted by apple entry since  $rF_X^A < \pi_D^A < \pi_{AAO}^{AO}$  always. An entrant may take advantage of this and try to take the apple monopoly away from the apple-orange producer. Since apples are more profitable than oranges, there will be times before  $\tau_D^A$  such that an entrant could enter apples, forcing the incumbent to leave apples immediately, and thereby earn more profits than if it waited until  $\tau_D^A$  to enter oranges and push the incumbent out of oranges. Let  $\tau_A^{MAO}$  be the earliest time such that the entrant would want to enter apples and take them away from an apple-orange producer.  $\tau_A^{MAO}$  is defined by

$$\int_{\tau_A^{MAO}}^T e^{-rt} \pi_D^A(t) dt - e^{-r\tau_A^{MAO}} F_E^A = \Pi_2$$

If an apple-orange monopolist maintains his position in both goods after  $\tau_A^{MAO}$ , then the other firm will enter apples sometime between  $\tau_A^{MAO}$  and the time at which the multiproduct incumbent is planning to leave oranges, thereby capturing the apple market and making more money than if he had been chosen to begin an orange monopoly at  $\tau_D^A$ . At this point we should digress, giving a more detailed proof highlighting the usefulness of the particular structure we chose for the game. Suppose that the interval between successive moves is some infinitesimally small positive  $\varepsilon$  and that firm one may move at times  $t_{2n+1} \equiv (2n+1)\varepsilon$  and firm two may move at times  $t_{2n} \equiv 2n\varepsilon$ , where  $n$  is any positive integer. If firm one, the incumbent, is in apples and oranges at some  $t_{2n}$  where  $\pi_D^A(t_{2n}) > e^{r\varepsilon} rF_E^A$ , then firm two will surely enter apples since the opportunity cost of the entry investment is covered by duopoly apple profits. Hence, at  $t_{2n} - \varepsilon$ , firm one will surely want to exit oranges since otherwise it will be immediately forced into producing only the less profitable oranges. To preempt that, at  $t_{2n} - 2\varepsilon$  firm two will surely enter

apples and drive out firm one, if doing so is preferable to waiting and entering oranges later. This backwards induction continues until we approach  $\tau_A^{MAO}$ . By definition, two will not enter apples before  $\tau_A^{MAO}$  even though it would drive one out of apples. However, our inductive argument shows that two will enter the first chance it gets after  $\tau_A^{MAO}$  if one continues to produce both goods. Hence, an apple-orange monopolist will withdraw from oranges at (or infinitesimally before)  $\tau_A^{MAO}$ .

Third, at some time,  $\tau_{MAO}^A$ , the extra profit flow from extending an apple monopoly to an apple and orange monopoly will cover the opportunity cost of entry capital, i.e.,

$$\pi_M^{AO}(\tau_{MAO}^A) - \pi_M^A(\tau_{MAO}^A) = rF_E^O.$$

At this time an incumbent producing only apples may decide to enter oranges also. Whether or not he does depends on the length of time such a two-good product line is safe from entry. The incumbent will introduce oranges at  $\tau_{MAO}^A$  if the present value of the extra rents due to producing oranges between  $\tau_{MAO}^A$  and  $\tau_A^{MAO}$  exceed the present value of the fixed costs of entering oranges at  $\tau_{MAO}^A$  and exiting at  $\tau_A^{MAO}$ . If  $\tau_A^{MAO} < \tau_{MAO}^A$ , then orange entry would bring about successful apple entry by the competitor. In this case, the orange entry is not made.

It is now clear that if a firm produces apples by  $t < \tau_{MAO}^A$ , then it may enter oranges at  $\tau_{MAO}^A$ , will certainly be out of oranges at  $\tau_A^{MAO}$ , after which a second firm enters oranges at  $\tau_D^A$  and the differentiated duopoly persists thereafter. One could similarly analyze the case where the first firm produces oranges only. However, since apples are more profitable, the first firm will not choose entry into oranges.

The final point to be pinned down is the time at which the first firm enters the apple market. Since we are examining the closed-loop equilibrium, both firms must earn the profits. Hence, the time at which the first firm enters apples is the first time,  $\tau_A$ , at which entry by the first firm will give it profits with present value  $\Pi_2$ . Note that in this case where preemption is not possible, both firms make positive profits whereas we saw that when an incumbent could preempt entry, all rents were competed away in the fight to be that incumbent.

In summary, this equilibrium of our entry-exit game in real time has five phases. Initially, there is no production of either good. Second, a firm enters apples. Third, that firm may temporarily produce both goods. Fourth, the incumbent firm withdraws from oranges if it did produce them because otherwise its position in apples is vulnerable to entry. During this fourth phase, only apples are produced. Finally, we reach a fifth phase where we have a differentiated duopoly.

Note that this real time game has an equilibrium which is similar to the stylized game studied in the previous. In equilibrium, one firm does enter first, taking into account responses of the second. This gives some justification for our examination of that stylized game as opposed to others.

If there were three potential producers, the results differ in a straightforward fashion. Since  $rF_E^A > \pi_{AA}^A$  and  $rF_E^O > \pi_{OO}^O$ , only two firms may survive in equilibrium. Since all firms must earn the same profits in equilibrium, all firms will earn zero profits. This forces the first firm to enter apples earlier and leave oranges earlier, lessening the likelihood that they would expand to oranges at all. Also, the second firm would enter oranges earlier.

Recall that Eaton and Lipsey (1979) argued that as a market grows and other products become viable, the incumbent has the greater incentive to produce them since profits to a multi-product monopoly exceed duopoly profits. However, to reach this result, they implicitly assumed that an incumbent multi-product monopoly would not withdraw any good in response to entry. We see here that allowing exit substantially changes the results. Since it seems reasonable to assume that exit costs are not high, this is an important alteration.

#### 6. Multiproduct Firm Rivalry

Now that we have established that incumbents may find it difficult to preempt entry into a market, we next ask whether a fixed number of firms will segment the market with each firm specializing or if the firms will choose to penetrate each others markets. An example could be the auto industry. Instead of seeing three firms segmenting the market, one producing small cars, one specializing in intermediate-size cars, and the third selling luxury models, we see three (domestic) firms each competing in all three submarkets. In this section, we examine a simple model and find that only when we allow exit do we find an equilibrium market structure with this sort of cross-penetration.

To avoid the tedious details associated with an analysis as general as that conducted above, we will consider a special case which will nonetheless illustrate the essential point. Suppose we have four goods -  $A$ ,  $O$ ,  $A'$ , and  $O'$ .  $A$  and  $O$  are substitutes as are  $A'$  and  $O'$ , but there are no cross-effects between the primed and unprimed goods. Assume that  $A$  and  $A'$  are both more profitable than  $O$  and  $O'$ , but  $A$  and  $A'$  are equally profitable, as are  $O$  and  $O'$ . Also assume that entry costs are sufficiently large that undifferentiated competition is unprofitable, but small enough to insure entry into all goods.

Brander and Eaton (1983) examined two games to model entry and equilibrium product line rivalry. First, they assumed that entry decisions are made simultaneously with no later chance for exit. There are clearly multiple equilibria because if one firm enters  $n$  markets, then it is optimal for the other firm to enter the other  $4-n$  markets. This game does not have any predictive power. It is also clear from our earlier analysis that it does not faithfully represent more realistic models where the market grows.

In the second game they examined, the "first" firm is allowed to commit itself to produce a prescribed number of goods and the "second" firm is then allowed to make entry decisions with no possibility of later exit. It is obvious that the first firm will enter as many as possible, preferring to monopolize a market segment before it enters another. For example, if each firm is able to produce only two goods, the first will enter  $A$  and  $O$  (or  $A'$  and  $O'$ ), and the second firm will produce the other two goods. In this case, we have a tendency towards market segmentation. Also, if each firm can produce all goods, the first firm will do so, preempting the second.

However, if we add an exit stage to this last game and assume that exit costs are small, these results are altered. If there are no limits to the number of goods produced by each firm, then the unique equilibrium will have the first firm producing  $A$  and  $A'$ , and the other producing  $O$  and  $O'$ . This follows as above from a few basic considerations. (i)  $A'$  and  $A$  are more profitable than  $O$  and  $O'$ ; (ii) if the first firm initially enters, say,  $A$ ,  $A'$ , and  $O$ , then the second firm can enter  $A$  and  $O'$ , driving the first firm out of  $A$ ; (iii) if firm one enters  $A$  and  $O$ , then two will respond with  $A$ ,  $A'$ , and  $O'$ , driving one out of  $A$ ; (iv) if one enters everywhere, two will respond with  $A$  and  $A'$ , driving one out of  $A$  and  $A'$ . Hence, in this game, we find that with low exit costs the unique equilibrium involves the sort of cross-penetration



and differentiated competition that characterizes many industries.

## 7. Conclusions

We have demonstrated in this paper that credible preemption by a multiproduct incumbent may be impossible unless his costs of exit are high. Low exit costs substantially weakens the ability of incumbents to keep entrants out of a differentiated market and leads to multifirm equilibria without assuming decreasing returns to scale or diseconomies of scope for firms. Since exit costs are probably small, this analysis limits the applicability of previous work which implies a more concentrated equilibrium market structure and consequently inferior performance.

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