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It is often argued that incumbent firms may deter entry by preemptive investment in new goods. We show that these conclusions are reversed when multiproduct incumbent firms may exit in response to entry. Once entrants are in an industry, an incumbent will often want to withdraw some goods to prevent competition with the entrant from reducing profits on other goods. Such a reaction makes entry more attractive to a potential entrant. The equilibrium industry structure is less likely to be monopolistic as the goods are better substitutes, as exit costs are low, and as the competition between producers of the same good is more intense.

1. Introduction

■ It is often argued that incumbent firms may deter entry by making the entry investment before the entrant does. For example, Schmalensee (1978) and Eaton and Lipsey (1979) argue that an incumbent firm may deter entry into substitutes by being the first firm to produce the new goods and by crowding the product spectrum sufficiently to leave no niche for potential entrants. We show that their conclusions are substantially altered when one allows multiproduct incumbent firms to exit in response to entry instead of implicitly assuming prohibitively high exit costs. Since the costs of withdrawing a product are often low, this analysis suggests that preemption by crowding may not be an important barrier to entry.

The basic insight is illustrated by the following tale. Suppose that there are two goods, apples and oranges, both produced at constant marginal cost after a fixed and irretrievable set-up cost is borne. Also assume that competition is in prices. If one firm produced both goods, then it appears that rational entry could not occur: if a second firm entered apples, the postentry price competition in apples would drive apple prices to marginal cost and apple profits to zero, so costly entry would be unprofitable. Since such entry appears to be irrational, an incumbent orange firm may believe that it could deter entry into the fruit industry by being the first to produce apples. This is the argument made in earlier analyses: by ensuring intensive postentry competition, the incumbent may deter entry and even extend its market power to close substitutes if the diseconomies of scope are not severe.

We demonstrate that it may not be credible, however, for the multiproduct incumbent

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to threaten an entrant with intense postentry competition. Suppose entry into apples did occur. As long as both the incumbent and the entrant stayed in the apple market, apple profits would be zero for both. While this apple "price war" continues, however, demand for any substitute, e.g., oranges, will be depressed. Continuing the price war means no apple profits and small orange profits for the multiproduct firm. Although the price war also yields 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 yield 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 postentry game, a firm will enter if the entry costs are covered by the rents that accrue to a differentiated duopolist. Since the relevant postentry benchmark is differentiated duopoly instead of head-to-head undifferentiated competition with the incumbent, entry is more likely than previous analyses indicate. Therefore, intensive postentry competition may *facilitate* entry. In particular, crowding the product spectrum will not credibly deter entry unless an incumbent's exit costs are high.

Note that this argument makes a critical distinction between exit costs on the one hand and irretrievably sunk costs of entry on the other. High entry costs, such as irreversible investment in product-specific capital, do not affect rational choice after both firms have entered. The advantages of exit to a multiproduct incumbent faced with entry are unaffected by such sunk costs. On the other hand, the level of exit costs, that is, the costs arising only because of the act of exit, are important and may lead the incumbent to remain in a market even after entry. We find that when entry costs are not so high as to blockade entry, it will be exit costs, not sunk entry costs, that deter entry against a multiproduct incumbent.

This article develops these points in a stylized dynamic game.[1] Section 2 extends the Prescott and Visscher (1977) analysis of foresighted entry by allowing exit in response to entry. Section 3 lists and discusses the assumptions of our analysis and computes equilibria for various cases. Section 4 compares our analysis with a well-known case of deterred entry. Section 5 explores the implications of our results for the crowding arguments in Schmalensee (1978) and compares our analysis with the entry analyses of Eaton and Lipsey (1980) and Gelman and Salop (1983). We also discuss various strategies firms may use to raise exit costs. Section 6 concludes our study.

2. The general model and equilibrium concept

■ The basic points can be made in a model with two goods, called apples and oranges. It will be clear that the basic argument is general in nature, but a detailed general analysis would be excessively tedious. For the same reasons of tractability, we also assume that there are two firms which could potentially produce these goods. The crucial feature is that there are no fewer products than firms. Let N, A, O, and AO represent the state of a firm's being in no market, being in apples only, in oranges only, and in both apples and oranges, respectively. The market structure is therefore given by the states of the two firms. Since identifying the nature of competition once a market structure is determined—Bertrand, Cournot, collusive, or otherwise—is not essential, we shall not so confine the analysis. The crucial elements are firms' profits under various market structures and the level of entry and exit costs. Let $R(S_1, S_2)$ be the revenue net of production costs to a firm in state S_1 if its competitor is in state S_2, where $S_i = N, A, O$, or AO, for $i = 1, 2$. R includes any fixed production costs that could be avoided by a firm if it chose to produce nothing of a good for which it has paid the entry costs. In addition to production costs, there may be entry

[1] A continuous-time, repeated game version of this analysis appears in Judd (1983).

and exit costs borne by a firm. Therefore, F_E^i is the nonnegative fixed entry cost into good i and F_X^i is the exit cost for good i, $i = A, O$.[2]

Some may argue with some semantic aspects of this accounting. The substance of the assumptions is contained in the following, where S_2 represents the state of the competing firm at the time of production and sales: (i) if a firm enters and then exits the market for good i, it will earn no revenues but bear the entry and exit costs and will receive a final payoff of $-F_E^i - F_X^i$, $i = A, O$; (ii) if a firm enters and produces only good i, then its final payoff is $R(i, S_2) - F_E^i$, $i = A, O$; (iii) if a firm enters and produces both goods, its payoff is $R(AO, S_2) - F_E^A - F_E^O$; and, (iv) if a firm enters both markets, but exits apples, then its final payoff is $R(A, S_2) - F_E^A - F_E^O - F_X^A$, and symmetrically if it exits oranges.

In this article we use a sequential equilibrium concept similar to that in Prescott and Visscher (1977) except for two features. While they restrict the number of products a firm may produce and make the (often expressed) argument that this is necessary to avoid a monopoly outcome, we impose no such restrictions. Second, we allow a firm to exit a market in response to a competitor's entry. Implicitly, entry has been assumed irreversible in earlier models. Since irreversibility of entry is distinct from the sunk nature of entry costs, however, such an assumption is very strong. We also assume that entry costs are sunk, but we allow exit. The addition of this exit stage adds an important element of realism and avoids identifying the sunk nature of investment costs with a commitment to be active in a market.

More formally, we examine a four-stage game. Figure 1 presents a flow diagram of the game. In the first stage player one enters apples, oranges, both markets, or none and pays the corresponding fixed costs of entry, F_E^A, F_E^O, $F_E^A + F_E^O$, or O, respectively. In the second stage firm two knows the stage-one choice of firm one and makes its entry decisions and bears the corresponding costs. There are four possible stage-two subgames, corresponding to the four possible decisions of firm one in stage one. In Section 3 two of these possible subgames are represented in the two columns of Table 4. The four possible decisions of firm two in stage two are represented in the rows of that table.

In the third stage both firms simultaneously make exit decisions, with a firm paying F_X^i if it exits market i. Each firm knows its competitor's entry choices in the previous entry stages. The second and third columns of Table 1 describe the initial condition of the 16 possible stage-three subgames, each representing a different combination of the firms' possible entry decisions in the preceding two stages. Of course, in stage three a firm can only exit those goods it entered in a previous entry stage. At the end of the third stage the market

FIGURE 1

FLOW DIAGRAM OF ENTRY–EXIT GAME

STAGE 1		STAGE 2		STAGE 3		STAGE 4
FIRM ONE ENTERS A, O, BOTH, OR NEITHER AND PAYS NECESSARY ENTRY COSTS.	→	FIRM TWO ENTERS A, O, BOTH, OR NEITHER AND PAYS NECESSARY ENTRY COSTS.	→	BOTH FIRMS MAKE EXIT CHOICES SIMULTANEOUSLY AND PAY NECES–SARY EXIT COSTS.	→	FIRMS PLAY THE DUOPOLY GAME OF THE FINAL MARKET STRUCTURE, BEAR PRODUCTION COSTS, AND EARN SALES REVENUE.

[2] To make clear our labelling of various costs, imagine the following case. Upon entry a firm spends ten dollars in equipment and installation costs, hires workers, and promises them four dollars if it fires them without using any of their labor. Also, suppose that the equipment could be sold for seven dollars if the firm decided to exit before production commenced. Therefore, the fixed entry cost is three dollars, since that was the net irretrievable expense; the exit cost is four dollars, since that is the severance pay to workers; and the fixed production cost is seven dollars, since that is the postentry opportunity cost of the equipment and is borne only if actual production occurs.

TABLE 1 Stage-Three Equilibria under Assumptions 1–9

	Initial States		Final States	
Case	Firm 1	Firm 2	Firm 1	Firm 2
1	*N*	*N*	*N*	*N*
2	*N*	*A*	*N*	*A*
3	*N*	*O*	*N*	*O*
4	*N*	*AO*	*N*	*AO*
5	*A*	*N*	*A*	*N*
6	*A*	*A*	*A*	*A*
7	*A*	*O*	*A*	*O*
8	*A*	*AO*	*A*	*O*
9	*O*	*N*	*O*	*N*
10	*O*	*A*	*O*	*A*
11	*O*	*O*	*O*	*O*
12	*O*	*AO*	*O*	*A*
13	*AO*	*N*	*AO*	*N*
14	*AO*	*A*	*O*	*A*
15	*AO*	*O*	*A*	*O*
16	*AO*	*AO*	$\{AO, A, O\}$	$\{AO, A, O\}$

structure is in place and is public knowledge.[3] Finally, in the fourth stage the two firms engage in the duopolistic competition corresponding to the final market structure, the payoff of which is given by the appropriate R defined above.

Assuming that at each stage each player chooses the option that yields the highest payoff given the state of the game and his competitor's strategy, we shall solve for subgame-perfect Nash equilibria of this game. Since the exact statement of our result comes in the next section only after a lengthy presentation of assumptions and analysis, we now state the basic result.

Basic result. If market demand is sufficient for differentiated duopoly to be profitable net of entry costs, if the goods are substitutes, if competition in homogeneous good markets is intense, and if exit costs are low, then in equilibrium the incumbent firm produces only the more profitable good, does not crowd the product space, and allows entry.

3. Specific assumptions and determination of equilibrium

■ Having described the general game we shall analyze, we now state precisely the particular assumptions concerning the payoff function, $R(\cdot, \cdot)$ which we regard as appropriate and interesting for the case of multiproduct competition. There are several reasonable assumptions to make concerning relations among these profit flows. This section presents a set of assumptions and proves the basic result under those assumptions. These assumptions are intuitive and are shown in the Appendix to be consistent with some common duopoly models.

[3] As is usually the case, the assumption of simultaneous exit decisions in stage three is crucial to the analysis since it rules out either firm's being able to make an absolute commitment to staying in a market before its competitor makes its exit decision. This choice is justified in Judd (1983), where we show that it is the correct static approximation of a truly dynamic analysis of entry into a growing market. Intuitively, in a continuous-time analysis, no one firm can commit itself to staying since tomorrow will give another chance to exit. Therefore, simultaneous exit is a good static approximation.

We first assume that postentry profits are always nonnegative. This holds as long as *postentry* economies of scale are not so severe that competition forces profits to be negative. This assumption is necessary if we are to avoid inessential complications. Hence, we assume the following:

Assumption 1. $R \geqslant R(AO, AO) \geqslant 0$.

To focus on preemption issues, we next assume that entry costs are sufficiently high that it does not pay a firm to enter a market if it will not eventually have a monopoly in the good. More precisely, we assume:

Assumption 2. $F_E^O > R(O, AO), R(O, O), (F_E^A > R(A, AO), R(A, A))$.

If Assumption 2 were not true, then no strategy by an incumbent could keep the entrant out of the market. This assumption is implicitly made in the work of Schmalensee and Eaton and Lipsey, for example.

Since the goods are to be imperfect substitutes, Assumption 3 is a natural assumption embodying this.

Assumption 3. $R(AO, A) > R(A, A) \geqslant R(A, AO), (R(AO, O) > R(O, O) \geqslant R(O, AO))$.

Assumption 3 states that a single-product firm facing competition in that good will receive more profits (gross of entry costs) if it introduces the other good, and may lose revenue if its opponent expands into the other good.

Since one good is likely to be more profitable, Assumption 4 chooses apples to be the more profitable good.

Assumption 4. $R(A, O) - F_E^A > R(O, A) - F_E^O$ and $R(A, N) - F_E^A > R(O, N) - F_E^O, 0$.

Assumption 4 says that apples are more profitable with or without the presence of oranges, and even when we take into account entry costs.

We shall now solve for the equilibrium of our game under Assumptions 1 through 4. There are several cases depending on the level of entry and exit costs. Since this study is concerned with their impact on equilibrium, it is appropriate to leave their levels as variables of our analysis. We first analyze the game completely for one interesting collection of assumptions which implies one range of values for the fixed costs and illustrates our basic result. This collection also leads to the most complex equilibrium analysis and makes it the most appropriate to study carefully. We then turn to the other cases and indicate the resulting adjustments in the equilibrium analysis.

Suppose initially that Assumptions 5 through 9 hold.

Assumption 5. $R(AO, N) - F_E^O - F_E^A > R(A, N) - F_E^A$.

Assumption 6. $R(A, O) - F_E^A > 0$.

Assumption 7. $R(O, A) - F_E^O > 0$.

Assumption 8. $R(A, O) - F_X^O > R(AO, O)$.

Assumption 9. $R(O, A) - F_X^A > R(AO, A)$.

Assumption 5, together with 4, states that it is more profitable to be a monopolist in both goods than in either one alone. Hence, if there were no threat of entry, firm one would immediately enter both goods. Assumptions 6 and 7 state that if one firm is producing one good, then another firm could profitably enter the other product.

Assumptions 8 and 9 state that it is better to be a differentiated duopolist than a multiproduct firm competing head-to-head in one of the products, even if the multiproduct firm must bear exit costs to become a differentiated duopolist. These conditions are the crucial ones for the purposes of this essay. Assumptions 8 and 9 implicitly assume that apples and oranges are good substitutes and that head-to-head competition is intense. These conditions also rule out substantial economies of scope, which would give a technological bias towards concentration. Since the earlier arguments concerning preemption do not assume economies of scope, neither shall we.[4]

We shall first make Assumptions 5 through 9 along with 1 through 4 since they form the set of assumptions yielding the novel results and shall solve for equilibrium under those conditions. Then we shall go through all possible combinations of Assumptions 5 through 9 holding and failing, which will lead to a complete equilibrium analysis of the model given by Assumptions 1 through 4.

To find equilibria under Assumptions 1 through 9 we solve all subgames, starting with the last. The fourth-stage outcomes are summarized in the R'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. Table 1 lists the possible states of the industry just before stage three and the resulting final states in equilibrium at the end of the stage-three game under Assumptions 1–9. Some of the cases have trivial or obvious equilibrium final states. In cases 1, 2, 3, 4, 5, 9, and 13, the final state in stage three is a monopoly since the initial state is monopolistic and firms can only exit in stage three. In these cases the monopoly firm will not want to withdraw any good since both are profitable, given that entry costs are sunk. Therefore, the final state is the same as the initial stage-three state for these cases.

Cases 6, 7, 10, and 11 are also obvious. Since each firm has entered a single good, neither has any incentive to withdraw its product since Assumption 1 implies nonnegative profits for both.

The more interesting situations arise when both firms have entered a common market, as in cases 8, 12, 14, 15, and 16. In case 14 firm one has entered apples and oranges and firm two has entered apples. The resulting third-stage payoff matrix is displayed in Table 2. 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 firm two staying in apples and firm one making the best response. Firm one will certainly not exit oranges since Assumption 3 implies that staying in both dominates exiting oranges. Under Assumption 9 firm one will exit apples since the relatively low exit costs make it more desirable to leave apples and be a differentiated duopolist.

The case of firm one in both markets and firm two in oranges is clearly analogous. Similarly, 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 (case 16) is one where both firms are in both markets at the beginning of stage three. The payoff matrix for that stage-three subgame is displayed in Table 3. First

TABLE 2 **Stage-Three Game, Case 14**

	Firm 2	
Firm 1	Exit A	Stay in A
Exit A	$R(O, N) - F_X^A, -F_X^A$	$R(O, A) - F_X^A, R(A, O)$
Stay in Both	$R(AO, N), -F_X^A$	$R(AO, A), R(A, AO)$
Exit O	$R(A, N) - F_X^O, -F_X^A$	$R(A, A) - F_X^O, R(A, A)$
Exit Both	$-F_X^A - F_X^O, -F_X^A$	$-F_X^A - F_X^O, R(A, N)$

[4] See Bulow *et al.* (1985) for an interesting analysis of competition among multiproduct firms where economies of scope and scale generate cross effects on the cost side.

TABLE 3 **Stage-Three Game, Case 16 from Table 1**

Firm One \ Firm Two	Stay in Both	Exit A	Exit O	Exit Both
Stay in Both	$R(AO, AO)$, $R(AO, AO)$	$R(AO, O)$, $R(O, AO) - F_X^A$	$R(AO, A)$, $R(A, AO) - F_X^O$	$R(AO, N)$, $-F_X^A - F_X^O$
Exit A	$R(O, AO) - F_X^A$, $R(AO, O)$	$R(O, O) - F_X^A$, $R(O, O) - F_X^A$	$R(O, A) - F_X^A$, $R(A, O) - F_X^O$	$R(O, N) - F_X^A$, $-F_X^A - \mathrm{F}_X^O$
Exit O	$R(A, AO) - F_X^O$, $R(AO, A)$	$R(A, O) - F_X^O$, $R(O, A) - F_X^A$	$R(A, A) - F_X^O$, $R(A, A) - F_X^O$	$R(A, N) - F_X^O$, $F_X^A - F_X^O$
Exit Both	$-F_X^A - F_X^O$, $R(AO, N)$	$-F_X^A - F_X^O$, $R(O, N) - F_X^A$	$-F_X^A - F_X^O$, $R(A, N) - F_X^O$	$-F_X^A - F_X^O$, $-F_X^A - F_X^O$

note that Assumption 1 implies that "stay in both" dominates "exit both" for both players and allows us to drop any consideration of the "exit both" strategy. By Assumptions 8 and 9 two possible equilibrium outcomes have one firm leaving apples and the other leaving 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., each firm independently leaves apples or oranges with positive probability. An even worse possibility would be for each to stay in both markets. This outcome would be a Nash equilibrium if $R(A, AO)$ and $R(O, AO)$ are so low that $R(A, AO) - F_X^O$, $R(O, AO) - F_X^A < R(AO, AO)$. High exit costs make exit in case 16 less likely and thus there is a more competitive final market structure. While there may be multiple equilibria, for the purposes of our analysis we need only note that the best equilibrium from the point of view of a particular firm is for it to leave oranges and for the other to leave apples; this provides an upper bound for each firm's payoff. The key fact will be that no firm would find it advantageous to bring about this third-stage market structure since it would either immediately leave one of the markets it had just entered, or stay and face head-to-head competition and earn low profits.

Now that we have computed the equilibrium outcomes for all possible stage-three subgames, we next analyze the possible stage-two subgames. The second-stage game is not so complex since firm two is faced with only four possible situations, some trivial. First, if firm one has entered no market, then firm two is effectively a monopolist, entering both markets by Assumption 5.

The other three cases are where firm one has entered one market or both. Table 4 is the payoff matrix for stage two if firm one chose to enter either apples only or both apples and oranges in stage one. The choices of firm two in these cases are represented by the rows of Table 4. Each entry, (π^1, π^2), represents the profit net of entry and exit costs to firms one and two, respectively, after account is taken of entry costs and any exit costs which may be incurred in stage three. Each entry of Table 4 corresponds to one of the 16 possible stage-

TABLE 4 **Two Stage-Two Subgames for Firm 2 under Assumptions 1–9**

Firm 2 Entry Choice	Firm 1 Entry Choice: A	Firm 1 Entry Choice: AO
A	$R(A, A) - F_E^A$, $R(A, A) - F_E^A$	$\mathrm{R}(O, A) - F_E^O - F_E^A - F_X^A$, $R(A, O) - \mathrm{F}_E^A$
O	$R(A, O) - \mathrm{F}_E^A$, $R(O, A) - F_E^O$	$\mathrm{R}(A, O) - F_E^O - F_E^A - F_X^O$, $R(O, A) - F_E^O$
AO	$R(A, O) - F_E^A$, $R(O, A) - F_E^A - F_E^O - F_X^A$	$<\mathrm{R}(A, O) - F_E^O - F_E^A - F_X^O$, $<R(A, O) - F_E^O - F_E^A - F_X^O$
N	$R(A, N) - F_E^A$, O	$\mathrm{R}(AO, N) - F_E^A - F_E^O$, O

three subgames listed in Table 1 and takes into account the stage-three outcome. For example, the entry in Table 4 corresponding to firm two's entry into apples after firm one enters both goods includes the exit cost F_X^A incurred by firm one in the stage-three outcome in case 14, the resulting stage-three game.

If firm one enters only apples, then firm two can profitably enter oranges. It will not choose to enter both. If it did, it would leave apples in stage three by case 8 in Table 1. If it enters only apples in stage two, it realizes $R(A, A) - F_E^A$ in profits, which is negative by Assumption 2. On the other hand, it would earn $R(O, A) - F_E^O$ if it enters oranges instead, which is positive by Assumption 7. Therefore, if firm one is in apples, then firm two will enter oranges. Similarly, if firm one enters oranges in stage one (a case not covered in Table 4), firm two will enter only apples in stage two.

The most complex case arises 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 since cases 13 and 14 in Table 1 apply. If firm two enters both, case 16 applies, and the best it could hope for in stage three is that firm one drops apples and firm two drops oranges. A differentiated duopoly at best results in any case and yields the bound on payoffs displayed in Table 4. Note that firm two would expend both F_E^A and F_E^O by entering both markets. Hence, if it sees firm one in both markets in stage two, firm two will produce apples. This offers greater duopoly profits net of entry costs, since under Assumption 9 firm one will exit apples when faced with direct competition in apples.

Finally, we may solve for the stage-one choice of firm one. Firm one knows that if it enters both markets, it will eventually exit one of them. Hence, it should choose to enter apples since doing so yields greater net profits. Therefore, under Assumptions 1 through 9, the unique equilibrium has firm one entering apples and firm two entering oranges. This is the clearest case to illustrate our basic result that the incumbent cannot preempt entry by entering all markets first if exit costs are small, if goods are substitutes, and if postentry competition is intense in homogeneous good markets.

Having completely analyzed equilibrium under Assumptions 1 through 9, we next turn to the examination of equilibrium under various combinations of Assumptions 5 through 9 holding or failing to hold. Our basic result continues to hold under various alternatives. The crucial feature for a differentiated duopoly to result is that costs of exiting some good be small and that postentry competition in that good be sufficiently intense to drive out the incumbent. Since the arguments are only slight adjustments of the previous analysis, we shall only outline the necessary changes.

First, suppose one of Assumptions 8 or 9 fails, but all other assumptions hold. Therefore, a multiproduct firm will exit one of the goods when faced with undifferentiated competition. Nothing is changed in this case. Entering both markets is still not viable for firm one since firm two will enter that good from which firm one will exit when faced with head-to-head competition and force out the incumbent.

Second, suppose Assumption 5 fails. Then an apple incumbent facing no threat of entry would not expand to oranges since a multiproduct monopoly is not so valuable as a fruit monopoly producing only apples. If Assumption 7 also fails, an entrant will not enter oranges when faced with an apple competitor since duopoly orange profits are inadequate. Then, independent of the exit conditions, Assumptions 8 and 9, and the duopoly entry conditions, Assumptions 6 and 7, firm one enters apples and firm two does nothing since oranges are not sufficiently viable for anyone to produce. If, however, Assumption 7 held (implying under Assumption 4 that Assumption 6 also holds), then the entrant would enter in stage two if the incumbent were only in apples. If one of Assumptions 8 or 9 also holds, then if a multiproduct incumbent confronted with entry of a single product could not deter entry, he would exit, and therefore would enter only apples in stage one. If Assumptions 8 and 9 both fail, then deterrence is possible. In this case the incumbent would deter the entrant's orange entry in stage two if the resulting multiproduct monopoly profits, $R(AO, N) - F_E^A - F_E^O$, exceeded differentiated duopoly profits, $R(A, O) - F_E^A$.

Third, suppose Assumption 7 fails to hold, but one of Assumptions 8 or 9 holds along with 5 and 6. In this case firm one will enter only apples. Assumption 5 implies that oranges would be a profitable expansion for an apple monopolist, but if he does so expand, then either Assumption 9 holds and implies that firm two will enter apples and force firm one out of apples or Assumption 8 holds and firm two forces the incumbent out of oranges. Hence, firm one stays out of oranges to protect its position in apples. Also, firm two does not enter oranges since Assumption 7 fails. Hence, the threat of entry may reduce product availability since the apple producer wants to produce oranges but will not since an entrant would wrest apples from him if he did.

Fourth, suppose that either Assumption 6 or 8 fails and that either Assumption 7 or 9 fails to hold. This says that either an entrant would not find it profitable to produce oranges if a competitor produces apples, or an incumbent producing both cannot be pushed out of oranges, and similarly for apples. In this case, a monopolist would like to produce both (Assumption 5), and such a multiproduct position is viable for an incumbent since, for each good, either an entrant would not want to enter even if the incumbent withdrew or the incumbent would not withdraw in reaction to entry. Since Assumption 2 implies that no one would produce a good if he did not have a monopoly on that good, we conclude that firm one will enter both goods, and firm two will do nothing in this case.

Since we have covered all possible combinations of Assumptions 5 through 9 holding or failing, we have determined the equilibria under Assumptions 1 through 4.

Theorem 1. If Assumption 5 holds, the unique equilibrium of our four-stage entry-exit game is:

(i) firm one enters apples and firm two enters oranges if $R(A, O) - F_E^A > R(O, A) - F_E^O > 0$ and either $R(O, A) - F_X^A > R(AO, A)$ or $R(A, O) - F_X^O > R(AO, O)$;
(ii) only firm one enters, and it enters only apples if $R(O, A) - F_E^O < 0$ and either $R(A, N) - F_E^A > R(AO, N) - F_E^A - F_E^O$ or $R(O, A) - F_X^A > R(AO, A)$;
(iii) firm one enters both apples and oranges if either $R(A, O) - F_E^A < 0$ or $R(AO, A) > R(O, A) - F_X^A$, and either $R(O, A) - F_E^O < 0$ or $R(AO, O) > R(A, O) - F_X^O$.

On the other hand, if Assumption 5 fails, then the unique equilibrium is:

(iv) firm one enters both apples and oranges if $R(O, A) - F_E^O > 0$, $R(A, O) - F_X^O < R(AO, O)$, $R(O, A) - F_X^A < R(AO, A)$, and $R(AO, N) - F_E^A - F_E^O > R(A, O) - F_E^A$;
(v) otherwise, firm one enters only apples surely, and firm two enters oranges if and only if $R(A, O) - F_E^O > 0$.

The first three cases assume that an incumbent not threatened by entry would want to enter both goods. 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 expose firm one to entry in the more profitable apple market. This is the case where 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's entering either market. This occurs because 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.

Cases (iv) and (v) assume that an unthreatened incumbent would enter only apples. When faced with possible entry, however, the incumbent may enter both goods. If deterrence is possible, if the entrant would want to enter oranges against an apple incumbent, and if a multiproduct monopolist earns more than an apple producer in a differentiated duopoly, then the incumbent will produce both goods to prevent entry since the choice is between multiproduct monopoly profits and apple profits in differentiated duopoly. In this case the threat of entry causes an increase in variety. The eventual prices are monopolistic, however. If these conditions are not met, the incumbent produces just apples. The entrant enters oranges if and only if differentiated duopoly orange profits exceed the entry costs.

Theorem 1 is a detailed statement of equilibrium in our model. Cases (i) and (ii) are the most novel, and represent the cases alluded to in our basic result above. They display the importance of exit costs and product substitutability for the product spectrum choice of an incumbent in the presence of potential entry. We next compare this analysis with some other examples of preemption.

4. An example of deterred entry

■ This section compares the foregoing with a case where entry into a monopolized market is deterred owing to credible threats of intense postentry competition. Suppose that firms have access to the same technology—a fixed positive entry cost and a constant nonnegative marginal cost of production. Suppose there is currently a monopoly. If postentry competition would be in price, then postentry profits for both the incumbent and the entrant would be zero since the Bertrand equilibrium would yield marginal cost pricing. Since postentry 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 postentry profits could not cover the fixed entry cost.

In this well-known case the intense postentry competition makes entry unprofitable, and an incumbent monopolist is secure. If postentry competition is not so 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 led to believe that as the postentry competition is more intense, the likelihood of successful entry declines. This example is useful to keep in mind when thinking about these issues since it strongly contrasts with our analysis.

5. Discussion and comparisons

■ In our analysis raising one's exit costs is strategically advantageous since it makes more credible a commitment to stay. There are several ways which are possibly available to an incumbent to raise his exit costs. He could promise severance pay to employees fired if exit occurred. Another tactic would be to maintain large stocks of inputs and partially processed items. If the firm continues to exist, these stocks do not affect incentives since their true marginal cost is the replacement cost, whereas if exit occurred, these stocks lose value to the extent of their firm-specific value. The actual viability of these strategies is questionable, however. Suppose a multiproduct firm signs a contract with a worker stating that his employment is conditional on production of a particular good and that exit would yield severance pay for the employee. If the severance pay is low, when the firm exits it may be in the mutual interest of the firm and the worker to break the contract and transfer the worker to another product since ending the employment relationship would likely forfeit rents due to search costs and firm-specific human capital. In this case the severance pay is not a credible way to increase exit costs. Also, the costs of using these strategies may be high. Large severance pay could lead to incentives for employees to shirk, or even to engage in sabotage. Maintaining large inventories incurs substantial holding costs. In summary, these considerations reduce the effectiveness of such strategies.

Another interesting feature of this analysis is that sunk entry costs need not make preemption more feasible, where by preemption we mean producing a good to change a potential entrant's decision. Of course, if sunk entry costs are high, an entrant would not enter oranges, even if the incumbent did not produce oranges. If exit costs are low, and Assumptions 8 and 9 hold, we see that the presence of the imcumbent in oranges at the beginning of stage two will *not* affect the potential entrant's decision: he enters if and only if entry costs can be covered by orange profits in a differentiated monopoly. Since the presence of the incumbent is irrelevant in this case, we see that the sunk entry costs do not facilitate preemption. Only when exit costs are high does the presence of the incumbent affect entry decisions.

We next compare our analysis with that of Schmalensee (1978). He argued that an incumbent firm would preempt entry by brand proliferation, that is, introduce several similar products to leave no profitable niche for any entrant. He assumes that no brands would be withdrawn in response to entry. Even if entry occurred only between existing brands (as Schmalensee assumes), 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 12:00, 1:00, 2:00, etc. Also assume that entry at any point is unprofitable if the incumbent stands fast. According to Schmalensee, entry is thereby preempted. Suppose, however, 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. The entrant will charge a low price for the 12:30 good out of fear of being undercut by 12:00 and/or 1:00. The multiproduct firm will have to choose between lowering prices on the 12:00 and 1:00 goods, which would cause loss of sales of the 11:00 and 2:00 goods, or keeping prices high and seeing sales of 12:00 and 1:00 fall substantially. This dilemma is more intense as the existing goods are more crowded, thus increasing the likelihood that the entrant will undercut and compete with more goods than just his 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. Such exit would give the entrant incentive to raise his price since, with 12:00 and 1:00 goods gone, he will have a larger number of inframarginal customers to exploit relative to marginal customers for whom he competes with the multiproduct firm.

In any case if entering between existing goods is not successful in forcing the incumbent to withdraw, a direct attack may be successful. Again, assume constant marginal costs and competition in prices. If entry occurs at 12:00, then the price for that good will drop to marginal cost, and neither firm will make money on sales of 12:00 goods. If the 1:00 and 11:00 goods are close enough that their sales would increase if the 12:00 price increased above marginal cost, we would have a situation comparable to the simpler example studied above: the entrant has no incentive to leave the 12:00 good since he is not losing money, and the incumbent will therefore withdraw his 12:00 good since it is not yielding any profits, and exit will cause the 12:00 price to rise, thereby improving profitability of 11:00 and 1:00 goods. 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, successful entry may be enhanced as the incumbent initially crowds the product space since the increased cross effects among similar goods will bring more pressure on the incumbent to withdraw. Furthermore, products must be far apart to prevent entry. In fact, the preentry market area for the 12:00 good need not touch the market areas of either neighboring good for successful entry at 12:00. If competition is Bertrand, the crucial condition for successful entry at 12:00 is that marginal cost pricing of the 12:00 good reduces profits at 1:00 or 11:00. Of course, if products are far apart, intermediate entry becomes more attractive. We therefore see that crowding strategies are substantially limited if exit costs are not large.

Related to this is the strategy of using close substitutes to protect a particularly profitable good. Suppose that the 12:00 good is in high demand relative to the 11:00 and 1:00 goods. A producer of 12:00 goods may think that by offering 11:00 and 1:00 goods he could protect his 12:00 position since a nearby competitor at 2:00 would have to compete with the 1:00 good before affecting 12:00 sales. We saw above, however, that such reasoning is flawed. Extending to 11:00 and 1:00 goods weakens a 12:00 position because one's incentive to stay and to fight entry at 12:00 has been reduced. In general, we see that brand proliferation arguments for entry deterrence or "protection" cannot rest solely on high fixed entry costs, but must include either high exit costs or economies of scope.

Eaton and Lipsey (1980) also noticed that exit barriers can be used to deter entry. Our analyses are substantially different, however; in fact, the exit barrier they discussed would not work in this model. They examined a single-good market where the incumbent over-invests in the durability of firm-specific and product-specific capital. Since the capital has no value outside of that firm and market, the incumbent is sure to stay until the capital dies, even if entry occurs. This lag between entry and the incumbent's earliest possible exit time deters entry if entry costs are high and duopoly rents are low. Maintaining highly durable capital will increase this lag and possibly mean the difference between entry and no entry. If this firm were a multiproduct incumbent in stage two of our game, however, the durability of capital has no impact on the entry decisions of firm two nor on any exit decisions of firm one in stage three. This is the case because these durability expenditures are sunk costs, not exit costs. If an apple monopolist makes more profits against an orange producer than an apple-orange firm would, then the multiproduct firm will withdraw from oranges in response to orange entry if exit costs are small to avoid the reduced apple profits caused by head-to-head orange rivalry. Durability of orange capital will not matter if Assumption 8 holds. Therefore, capital durability may deter entry in a single-product market, but not in a multiproduct market.

Our analysis is similar in spirit to Gelman and Salop's (1983) "judo economics," where an entrant in a single-product market is allowed credibly to limit his capacity, thereby causing the incumbent to react less aggressively to the entry. In our model the entrant makes no price precommitment nor any capacity limitation in any market he enters, but by staying out of certain goods, he gives the incumbent an acceptable retreat. This scope limitation is qualitatively similar to the capacity limitation of Gelman and Salop.

The 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 that would lose sales during a fight with the entrant. This direct attack is more likely to be successful as the postentry game is more intensely competitive.

6. Conclusions

■ We have demonstrated in this article that credible preemption by a multiproduct incumbent may be impossible unless his costs of exit are high. Low exit costs substantially weaken the ability of an incumbent to keep entrants out of a differentiated industry and result in multifirm equilibria without assuming decreasing returns to scale or diseconomies of scope for firms. Since exit costs are probably small, this analysis limits the scope of previous work which predicts a more concentrated equilibrium market structure.

Appendix

■ To lend plausibility to the most interesting collection of basic assumptions, Assumptions 1 through 9, this Appendix offers two examples where they hold.

First, we offer an example with Cournot quantity competition which satisfies our assumptions. Let $U = X + Y - b(X^2 + Y^2)/2 - aXY + M$ be the utility of consuming X apples, Y oranges, and M dollars, where a and b are positive. Suppose m is the constant marginal cost of production and F_p^i equals fixed costs of production which are borne only if there is some production of good i, $i = A, O$. For example, F_p^i could be the preproduction (but postentry) market value of capital equipment acquired upon entry minus its postproduction salvage value. The resulting Cournot model assumes that each firm simultaneously makes output decisions for each of the products it has entered and not exited, with each firm knowing what products its competitor can produce. Since demand is linear in price and costs are linear in output, each firm's profits are linear-quadratic in the quantity decisions of the firms, and each firm's reaction curve is linear in its competitor's choice.

We first deal with the crucial Assumption 8 and, by symmetric arguments, Assumption 9. Tedious calculations show that the additional profits to an apple-orange firm from staying in oranges instead of exiting oranges when competing with an orange firm equal

$$\Delta \equiv R(AO, O) - (R(A, O) - F_X^O) = \frac{(1-m)^2(b-a)(16b^2 + 12ab + 5a^2)}{(2b+a)^2 36b(a+b)} - F_p^O + F_X^O. \tag{A1}$$

Assumption 8 holds if and only if $\Delta < 0$. If there are no fixed costs of production other than the already sunk entry costs, then $\Delta > 0$ and the firm will stay in oranges. If $F_p^O > O$, then Δ may be negative. Examination of Δ shows that Δ is negative if $b - a$ is small, or if F_p^O, b, a, or m are large: as goods are better substitutes, fixed or marginal production costs are larger, or as demand is less, the net value of staying in oranges for an apple-orange producer facing an orange competitor is more likely negative.

We next examine the other assumptions and their consistency with Assumptions 8 and 9. Additional calculations show that

$$R(AO, AO) = \frac{2(1-m)^2}{9(a+b)} - F_p^A - F_p^O. \tag{A2}$$

Assumption 1 puts an upper bound on the fixed production costs. Comparison of (A1) and (A2) shows that F_p^O may be large enough to make Δ negative, while still allowing R always to be positive. Therefore, the fixed production costs can be chosen to satisfy Assumption 1. Assumption 2 puts a lower bound on fixed entry costs, whereas Assumptions 5, 6, and 7 impose upper bounds. $R(A, O)$ obviously exceeds $R(A, A)$ and $R(A, AO)$. $R(AO, N) - R(O, N)$ exceeds $R(A, O)$ if $5b$ exceeds $13a$, a condition consistent with (A1). Therefore, the fixed cost of apple entry can be chosen to satisfy Assumption 2, 5, and 6. Similarly for the fixed cost of orange entry.

More tedious calculations show that

$$R(AO, A) = R(A, A) = \frac{(1-m)^2(b-a)}{4b(a+b)} - F_p^O - F_E^O \tag{A3}$$

and that $R(A, A) > R(A, AO)$ always. A similar formula arises when we interchange the goods. Comparison of (A1) and (A2) shows that Assumptions 8 and 3 both hold for some interval of values for fixed costs. Therefore, a firm engaged in head-to-head competition will find it profitable to introduce the other good if its entry and fixed production costs are not excessively high and if the other good is not an extremely close substitute. This shows that Assumption 3 also holds. In this example the goods are equally profitable, but an infinitesimal increase in the marginal utility of apples will yield Assumption 4 without affecting any of the other assumptions. This shows that our basic assumptions are consistent with Cournot competition with linear demand.

Second, if these firms instead engage in price competition and fixed production costs are zero, then our assumptions, including the critical Assumption 8, hold. If both firms produce a common good, its price will be driven to marginal cost in the price game. This implies that

$$R(A, A) = R(A, AO) = R(O, O) = R(O, AO) = R(AO, AO) = 0$$

if fixed costs of production are zero. On the other hand, differentiated duopoly will yield positive profits. This implies that $R(A, O)$ and $R(O, A)$ are equal and positive. Since a is positive, $R(O, A) > R(AO, A) = R(AO, O) > 0$. The validity of Assumptions 1 through 9 for moderate fixed entry costs follows directly.

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