

Multimarket Oligopoly: Strategic Substitutes and Complements

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A firm's actions in one market can change competitors' strategies in a second market by affecting its own marginal costs in that other market. Whether the action provides costs or benefits in the second market depends on (a) whether it increases or decreases marginal costs in the second market and (b) whether competitors' products are strategic substitutes or strategic complements. The latter distinction is determined by whether more "aggressive" play (e.g., lower price or higher quantity) by one firm in a market lowers or raises competing firms' marginal profitabilities in that market. Many recent results in oligopoly theory can be most easily understood in terms of strategic substitutes and complements.

I. Introduction

There are two main points to this paper. First, changes in a firm's opportunities in one market may affect its profits by influencing its

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competitors' (or potential competitors') strategies in a second oligopoly market. Second, two factors determine whether the resulting changes in competitors' strategies will raise or lower profits. They are (a) whether the two markets exhibit joint economies or diseconomies and (b) whether the competitors regard the products as *strategic substitutes* or *strategic complements*.

Strategic substitutes and complements are defined precisely in Section III, but we give a rough explanation now: Conventional substitutes and complements can be distinguished by whether a more "aggressive" strategy by firm A (e.g., lower price in price competition, greater quantity in quantity competition, increased advertising, etc.) lowers or raises firm B's *total* profits. *Strategic substitutes* and complements are analogously defined by whether a more "aggressive" strategy by A lowers or raises B's *marginal* profits.

When costs are interrelated across markets a tax, cost, or demand shock in a monopoly or competitive market 1 has both a direct effect on the profits of a firm (the extra profit or loss the firm would make in that market without any change in output levels) and an indirect effect. After the shock the firm's previous allocation of outputs between market 1 and its other markets is no longer profit maximizing, since the marginal gain from selling a unit in market 1 has changed. The firm will reoptimize. After a tax cut on output sold in market 1, for example, we will see that the firm increases output in market 1 and either increases or decreases output in a second market, market 2, depending on whether the markets exhibit joint economies or diseconomies.

For small enough shocks we know (by the envelope theorem) that the reoptimization has a negligible effect on the firm's profits if it is also a monopolist or pure competitor in market 2. But these marginal changes in strategy can have first-order effects on the firm's profits if it is an oligopolist in the second market. The reason is that small changes in firm A's equilibrium strategy in market 2 will cause small changes in its competitor B's marginal profit schedule and thus induce small changes in B's market 2 strategy. These small changes in B's strategy have first-order effects on A's profits.

This strategic effect on profits exists in virtually any oligopolistic setting, including price competition, quantity competition, and collusive behavior.

Section II provides a numerical example of the strategic effect. It is a simple Cournot model in which two firms sell in one market and one of them is a monopolist in the second market. The markets clear simultaneously so that the monopolist cannot precommit to staying out of the monopoly market. The strategic effect is so strong that a subsidy to sales in the monopoly market reduces the monopolist's total profits.

In Section III we develop a simple model of the strategic effect, precisely define strategic substitutes and complements, and show their importance in determining whether the strategic effect increases or decreases profits. One cannot determine whether products are strategic substitutes or complements without empirically analyzing a market. For example, quantity competition and constant elasticity demand may yield strategic complements, but a linear demand curve with the same elasticity around equilibrium will always yield strategic substitutes. Price competition, also, can give either strategic complements or strategic substitutes.

We extend the analysis (in Sec. IV) to models of sequential markets where a firm makes strategic choices in one period taking into account their impact in a second period. Whereas in simultaneous markets a firm may be hurt by a monopoly opportunity, such a result is not possible in sequential markets if the monopoly market clears first. On the other hand, in the sequential case a firm *may* produce in a market in which revenues are less than costs because of the strategic implications, but this cannot occur when markets operate simultaneously. Examples of sequential markets include models of the learning curve (see, e.g., Spence 1981; Lieberman 1982; Fudenberg and Tirole 1983). We show the analogy to models in which firms make capacity investments in one period to deter entry in a second period (as in Spence 1977; Dixit 1980). In contrast to the earlier literature, we show that (with strategic complements) firms may strategically *underinvest* in capital to reduce the ferocity of future competition. Baldani (1983) and Schmalensee (1983) present related models with strategic effects in advertising. Many of the results of our sequential analysis have been developed independently by Fudenberg and Tirole (1984).

In Section V we explore the special cases of quantity competition and price competition. In each case we give intuitive criteria for determining whether we have strategic substitutes or complements.

Section VI gives a series of applications in a variety of oligopolistic settings. We show that the choice of strategic assumption (strategic substitutes or complements) is the crucial determinant of the results of many oligopoly models.

We conclude in Section VII.

II. Numerical Example

Consider a firm A that is a monopolist in market 1 and a duopolist with firm B in market 2. Assume that demand is infinitely elastic in market 1 at $p_1 = 50$ and that inverse demand in market 2 is $p_2 = 200 - q_2^A - q_2^B$, where q_j^i is the output of firm i in market j . Total costs for A are $C^A = F + \frac{1}{2}(q_1^A + q_2^A)^2$ and total costs for B are, symmetrically,

$C^B = F + \frac{1}{2}(q_2^B)^2$. We assume $F > 1,512\frac{1}{2}$; the fixed cost is relevant only because it prevents firms from wanting to set up multiple plants. For $F > 1,512\frac{1}{2}$, firms' average costs will always be decreasing in the relevant range, even though marginal costs are increasing.

In Cournot equilibrium $q_1^A = 0$, $q_2^A = q_2^B = 50$. Each firm earns profits of $3,750 - F$. Marginal revenue equals marginal cost of 50 for each firm in the markets in which it operates.

Now imagine that something happens to either increase A's marginal revenue schedule or decrease its marginal cost schedule in market 1. For example, assume that a demand shock raises the price in market 1 to 55 or, equivalently, A is offered a subsidy of 5 for each unit sold in market 1.

The Cournot equilibrium is now $q_1^A = 8$, $q_2^A = 47$, $q_2^B = 51$. Marginal revenue equals marginal cost of 55 in both markets for A, and $MR = MC = 51$ in market 2 for firm B. Firm B's profits rise to $3,901\frac{1}{2} - F$, but A's profits fall to $3,721\frac{1}{2} - F$. The "positive" shock to market 1 has hurt A.¹

We stress that the example does *not* depend on the assumption of a Cournot-Nash equilibrium. Nor does it rely on the particular functional forms chosen. Similar examples are possible whenever A has joint economies or diseconomies of scope, that is, $\partial^2 C^A / \partial q_1^A \partial q_2^A \neq 0$. The main point of this example, however, is not the counterintuitive result that an increase in price in its monopoly market may hurt a firm—we would argue that if A knew that the price in market 1 would not exceed 55 it would find some way to precommit to not selling in that market. We constructed the example to dramatize a more modest claim—that in general A's gain in profits from a change in market 1 is *different* when it is an oligopolist in market 2 than when it is a monopolist or pure competitor in that market.

III. Strategic Substitutes and Complements

How could A lose from its increased profitability in market 1? If firm B had not changed its strategy from the preshock equilibrium, then clearly A would make more money as market 1 became more profitable. Thus it is the "strategic effect" of the change in B's equilibrium strategy on A's profits that has overwhelmed any direct positive effect of the shock. In this section we present a simple model of the strategic effect and discuss the intuition behind it.

¹ If the two firms are able to achieve the Nash bargaining solution, splitting profits so that each gets the same gain over its "threat point" of forcing the Nash quantity equilibrium, then each firm would earn $4,062\frac{1}{2} - F$ before the shock. After the shock firm B would earn $4,180\frac{1}{2} - F$ and A would earn $4,000\frac{1}{2} - F$. Again A is hurt by the greater profitability of its monopoly market.

The simplest model of the strategic effect assumes that firm A is a monopolist in one market, market 1, and a duopolist with B in another market, market 2.² Firm A chooses strategic variables S_1^A and S_2^A , and B simultaneously chooses S_2^B . Assume that a higher level chosen for this variable indicates more "aggressive" play. For example, if firms choose quantities or levels of advertising, then S_1^A , S_2^A , and S_2^B can be thought of as the quantities of output or amounts of advertising that the firms choose. If, however, firms choose prices then, because *low* prices are a sign of aggressive play, S_1^A , S_2^A , and S_2^B can be thought of as the *inverses* of prices charged. Without loss of generality we can assume in market 1 that $S_1^A = q_1^A$, because as a monopolist in market 1 firm A will implicitly be choosing its quantity there even if it thinks of its strategic variable as price or advertising. Demand is assumed to be independent across markets.³

Finally, we assume that there is a "shock" variable Z that affects the profitability of market 1. An increase in Z of one unit can be interpreted as either shifting A's marginal revenue curve (as a function of quantity) in market 1 upward by one unit or shifting its marginal cost curve downward by one unit. Equivalently, it may be interpreted as a decrease in excise taxes paid by A in market 1 or an increase in a per unit subsidy A receives in that market.

R_i^F is the revenue of firm F in market i , assuming $Z = 0$, and C^F is the total cost of firm F, assuming $Z = 0$. Firm A earns profits of $\pi^A(S_1^A, S_2^A, S_2^B, Z) = R_1^A(S_1^A) + R_2^A(S_2^A, S_2^B) - C^A(S_1^A, S_2^A, S_2^B) + ZS_1^A$ (because $S_1^A = q_1^A$). Firm B, because it competes only in market 2, earns $\pi^B(S_2^A, S_2^B) = R_2^B(S_2^A, S_2^B) - C^B(S_2^A, S_2^B)$. If the profit functions are all differentiable, then there are three first-order conditions that must be satisfied at an interior Nash equilibrium:

$$\frac{\partial \pi^A}{\partial S_1^A} = \frac{\partial R_1^A}{\partial S_1^A} - \frac{\partial C^A}{\partial S_1^A} + Z = 0 \quad (1)$$

$$\frac{\partial \pi^A}{\partial S_2^A} = \frac{\partial R_2^A}{\partial S_2^A} - \frac{\partial C^A}{\partial S_2^A} = 0 \quad (2)$$

$$\frac{\partial \pi^B}{\partial S_2^B} = \frac{\partial R_2^B}{\partial S_2^B} - \frac{\partial C^B}{\partial S_2^B} = 0. \quad (3)$$

To examine the effect of a shock that makes market 1 marginally more profitable, we totally differentiate the first-order conditions:

² In Bulow, Geanakoplos, and Klemperer (1983) we consider a more general model with two firms simultaneously or sequentially competing in each of two markets. The propositions there can be generalized to many firms.

³ This assumption means that the only effect of S_1^A on the equilibrium choices of S_2^A and S_2^B comes from interrelated costs. In our applications section we generalize to the case where demands, rather than costs, are interrelated.

$$\frac{\partial^2 \pi^A}{\partial S_1^A \partial S_1^A} dS_1^A + \frac{\partial^2 \pi^A}{\partial S_1^A \partial S_2^A} dS_2^A + \frac{\partial^2 \pi^A}{\partial S_1^A \partial S_2^B} dS_2^B + \frac{\partial^2 \pi^A}{\partial S_1^A \partial Z} dZ = 0 \quad (4)$$

$$\frac{\partial^2 \pi^A}{\partial S_2^A \partial S_1^A} dS_1^A + \frac{\partial^2 \pi^A}{\partial S_2^A \partial S_2^A} dS_2^A + \frac{\partial^2 \pi^A}{\partial S_2^A \partial S_2^B} dS_2^B + \frac{\partial^2 \pi^A}{\partial S_2^A \partial Z} dZ = 0 \quad (5)$$

$$\frac{\partial^2 \pi^B}{\partial S_2^B \partial S_2^A} dS_2^A + \frac{\partial^2 \pi^B}{\partial S_2^B \partial S_2^B} dS_2^B = 0. \quad (6)$$

These equations can be further simplified by noting that $\partial \pi^A / \partial Z = q_1^A$. Therefore, $\partial^2 \pi^A / \partial S_1^A \partial Z = 1$, since $S_1^A = q_1^A$, and $\partial^2 \pi^A / \partial S_2^A \partial Z = \partial q_1^A / \partial S_2^A = 0$. Equations (4), (5), and (6) can thus be summarized as

$$\begin{pmatrix} \frac{\partial^2 \pi^A}{\partial S_1^A \partial S_1^A} & \frac{\partial^2 \pi^A}{\partial S_1^A \partial S_2^A} & \frac{\partial^2 \pi^A}{\partial S_1^A \partial S_2^B} \\ \frac{\partial^2 \pi^A}{\partial S_2^A \partial S_1^A} & \frac{\partial^2 \pi^A}{\partial S_2^A \partial S_2^A} & \frac{\partial^2 \pi^A}{\partial S_2^A \partial S_2^B} \\ 0 & \frac{\partial^2 \pi^B}{\partial S_2^B \partial S_2^A} & \frac{\partial^2 \pi^B}{\partial S_2^B \partial S_2^B} \end{pmatrix} \begin{pmatrix} dS_1^A \\ dS_2^A \\ dS_2^B \end{pmatrix} = \begin{pmatrix} -dZ \\ 0 \\ 0 \end{pmatrix}. \quad (7)$$

We assume that the equilibrium is locally strictly stable, which implies that the determinant $|\pi|$ of the matrix, π , in (7) is negative and that, in the absence of market 1, market 2 would still be strictly stable, hence that $\pi_{22} \pi_{33} > \pi_{32} \pi_{23}$.⁴ We also assume that the products are substitutes. That is, $\partial \pi^A / \partial S_2^B < 0$ and $\partial \pi^B / \partial S_2^A < 0$.

Note that if $\partial^2 \pi^A / \partial S_1^A \partial S_2^A = -\partial^2 C^A / \partial S_1^A \partial S_2^A < 0$ there are joint diseconomies, or diseconomies of scope, across markets (being more aggressive in one market and raising sales there lowers the marginal profits from being a little more aggressive in the other market), and if $\partial^2 \pi^A / \partial S_1^A \partial S_2^A > 0$ there are joint economies.⁵

It is now possible to solve (7) for dS_1^A/dZ , dS_2^A/dZ , and dS_2^B/dZ . The following results are easy to derive:

⁴ That is, if we adjust S_1^A , S_2^A , and S_2^B near the Nash equilibrium according to the usual rule $\dot{S}^K = \partial \pi^K / \partial S^K$, $K = A, B, j = 1, 2$ (i.e., if marginal revenue exceeds marginal cost, raise the corresponding strategic variable) then $d/dt[(\partial \pi^A / \partial S_1^A)^2 + (\partial \pi^A / \partial S_2^A)^2 + (\partial \pi^B / \partial S_2^B)^2] < 0$. If the matrix π is nonsingular, which generically it is, then it must be negative definite if the tâtonnement process is to be strictly stable. Hence $|\pi| < 0$ and $\pi_{22} \pi_{33} > \pi_{32} \pi_{23}$.

⁵ Alternatively, even if costs were unrelated across markets, $\partial^2 \pi^A / \partial S_1^A \partial S_2^A$ would generally be nonzero if demands in the two markets were interrelated. When the strategic variables S_1^A , S_2^A are quantities q_1^A , q_2^A , then our definition of joint economies has a natural interpretation in terms of technologically related marginal production costs across markets. When the strategic variables represent prices, then the costs of production must be multiplied by the induced changes in quantity. However, it is easy to show that the same technological relation between marginal production costs is again a proper interpretation.

1. $dS_1^\wedge/dZ > 0$: A positive shock to the marginal profitability of market 1 causes A to sell more there.

2. $\text{sign}(dS_2^\wedge/dZ) = \text{sign}(\partial^2\pi^A/\partial S_1^\wedge\partial S_2^\wedge)$. We know from result 1 above that, with a positive shock, in equilibrium A will sell more in market 1. Whether this leads A to adopt a more aggressive or less aggressive strategy in market 2 depends on whether the markets exhibit joint economies (more aggressive) or joint diseconomies (less aggressive).

3. $\text{sign}(dS_2^\wedge/dZ) = \text{sign}[(\partial^2\pi^A/\partial S_1^\wedge\partial S_2^\wedge) \cdot (\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge)]$. Whether firm B's equilibrium strategy is more or less aggressive depends on two things: (a) whether there are joint economies or diseconomies across markets (by result 2 this determines whether A is more or less aggressive in market 2), and (b) whether a more aggressive strategy by A in market 2 (increased S_2^\wedge) raises or lowers B's marginal profitability.

*Result 3 is the core of our paper.*⁶

Think of $\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge$ as $\partial/\partial S_2^\wedge(\partial\pi^B/\partial S_2^\wedge)$. That is, the term represents the change in the marginal profitability to firm B of being a bit more "aggressive" when firm A becomes more aggressive. In quantity competition, for example, this equals the change in firm B's marginal revenue when firm A increases its quantity. $\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge$ can be of either sign, both in differentiated or undifferentiated products quantity competition and in differentiated products price competition. For example, with undifferentiated products quantity competition and constant elasticity demand, $\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge$ is negative for equilibria in which q^B is small relative to q^A but positive for equilibria in which q^B is sufficiently large relative to q^A . If $\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge$ is negative, we say that B regards its product as a *strategic substitute* to A, and if $\partial^2\pi^B/\partial S_2^\wedge\partial S_2^\wedge > 0$ we say that B regards the products as *strategic complements*. Thus, with strategic substitutes B's optimal response to more aggressive play by A is to be *less aggressive* (B decreases S_2^\wedge). With strategic complements B responds to more aggressive play with *more aggressive play* (increases S_2^\wedge).

With conventionally defined substitutes, $\partial\pi^B/\partial S_2^\wedge < 0$: B earns less total profits if A adopts a more "aggressive" strategy. Similarly, with complements $\partial\pi^B/\partial S_2^\wedge > 0$. With *strategic* substitutes and complements we are concerned with the effect on *marginal* profitability. In the numerical example in Section II the markets had joint diseconomies, so an increase in profitability in market 1 implied an equilibrium decrease in $S_2^\wedge = q_2^\wedge$. With linear demand in a Cournot model, the decrease in q_2^\wedge caused an *increase* in firm B's marginal revenue curve so

⁶ Note that this result does not depend on the stability of market 2 in isolation: The sign of the strategic effect (which is the sign of dS_2^\wedge/dZ) is dependent only on the system as a whole being stable. The assumption that market 2 is stable is, however, needed in the analysis of sequential markets: Result 1 above is reversed if $\pi_{22}\pi_{33} < \pi_{32}\pi_{23}$.

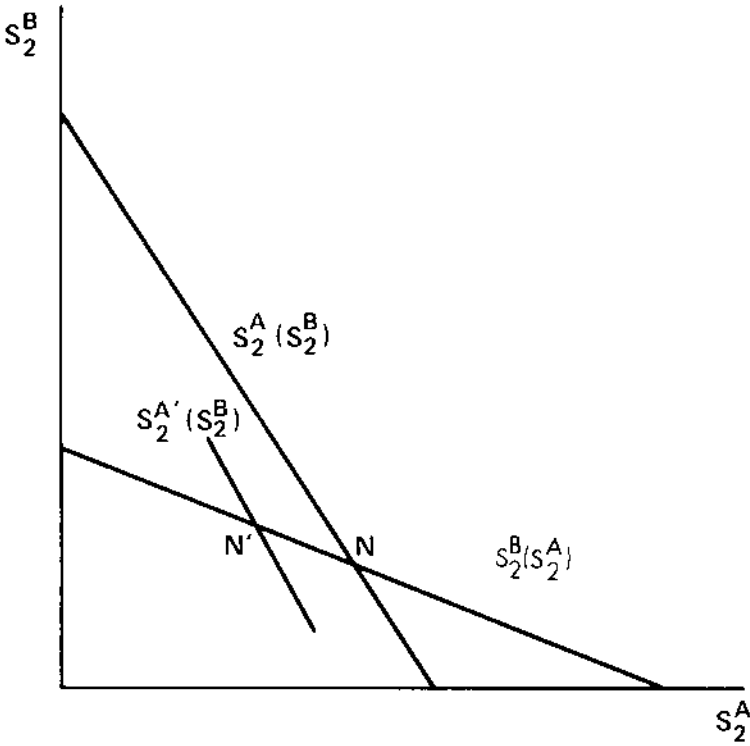


FIG. 1.—Reaction curves in an oligopoly market with strategic substitutes

$\partial^2 \pi^B / \partial S_2^B \partial S_2^A < 0$ (strategic substitutes). The net result is that B's equilibrium output (S_2^B) was increased by the profitability shock and A's profits were hurt. The sign of the strategic effect on A's profits is summarized below.

	Joint Economies	Joint Diseconomies
Strategic substitutes	+	-
Strategic complements	-	+

We can also explain our numerical example, and illustrate the analysis above, in terms of reaction curves. Figure 1 graphs the strategy of firm A in market 2 as a function of B's strategy, $S_2^A(S_2^B)$, and the strategy of B as a function of A's strategy, $S_2^B(S_2^A)$. The Nash equilibrium is at point N. Since the numerical example used linear demand and quantity competition, the products are strategic substitutes (when A's equilibrium quantity is increased, B's marginal profitability curve is shifted downward with linear demand and so B reduces quantity). Therefore both curves are downward sloping—if S_2^A is reduced B's

marginal profitability is increased and S_2^B will be raised, and vice versa.⁷

The demand shock in market 1, by increasing A's opportunity cost of selling in market 2, shifts A's reaction curve inward to $S_2^A(S_2^B)$. (Firm A increases its output in market 1, thus increasing its marginal costs in market 2 so that it will lower S_2^A for any given S_2^B .) The new Nash equilibrium is at N' . Firm A's strategic variable has decreased marginally, while B's strategic variable has increased slightly. At equilibrium $\partial\pi^A/\partial S_2^A = 0$, so that the slight change in S_2^A has a negligible effect on A's profits. But the small change in S_2^B has a first-order effect. In our numerical example, an increase in S_2^B of one unit reduces A's profits by \$1.00 times A's sales in market 2.

If firm A had joint economies across markets 1 and 2, a positive demand shock in market 1 would push A's market 2 reaction curve outward. In that case the new equilibrium would entail a slight decrease in S_2^B , providing a strategic benefit to A.

If (from B's viewpoint) the products were strategic complements, B's reaction curve would be upward sloping around N .⁸ The exact opposite results would then occur. With joint diseconomies both firms would be less aggressive so the strategic effect of the change in S_2^B on π^A would be positive. With joint economies both firms would be more aggressive and the change in S_2^B would hurt firm A.⁹

Finally, note that the counterintuitive result of reduced total profits for A when market 1 is made more profitable is generally true if the strategic effect is negative and sales in market 1 are sufficiently small. The total effect of a profitability shock, ΔZ , on A's profits is

$$(\Delta Z) \frac{d\pi^A}{dZ} = (\Delta Z) \left(\frac{\partial\pi^A}{\partial S_1^A} \frac{dS_1^A}{dZ} + \frac{\partial\pi^A}{\partial S_2^A} \frac{dS_2^A}{dZ} + \frac{\partial\pi^A}{\partial S_2^B} \frac{dS_2^B}{dZ} + \frac{\partial\pi^A}{\partial Z} \right). \quad (8)$$

⁷ Stability in market 2 if it operated in isolation, or subsequently to market 1, requires that on the axes chosen A's reaction curve $S_2^A(S_2^B)$ be steeper than B's.

⁸ The reader may check that it is not important whether A's reaction curve is upward or downward sloping provided that the equilibrium is stable.

⁹ Figure 1 illustrates how our results extend to markets connected on the demand side rather than (or as well as) on the cost side—see Sec. VIK. The crucial questions are, around equilibrium: (i) Does increasing A's activity in market 1 push A's market 2 reaction curve out or in? (ii) Does B's market 2 reaction curve slope down or up? The sign of the strategic effect on A's profits can then be determined as below:

B's reaction curve slopes:	A's reaction curve pushed:	
	Out	In
Down	+	-
Up	-	+

The first-order conditions assure that the first two terms in the parentheses on the right-hand side of (8) equal zero. The last term $\partial\pi^A/\partial Z = q_1^A$, which approaches zero if demand is sufficiently small. Therefore, if q_1^A is small enough, $\text{sign}(d\pi^A/dZ) = \text{sign}[(\partial\pi^A/\partial S_2^B)(dS_2^B/dZ)]$. Of course, $\partial\pi^A/\partial S_2^B < 0$ as long as the products are conventional substitutes. Whenever $dS_2^B/dZ > 0$, as is true with joint diseconomies and strategic substitutes or with joint economies and strategic complements, the result in Section II will hold.

The Effect on Entry

The strategic effect is the effect on the strategies of competitors who are committed to competing in market 2. However, a profitability shock to firm A in market 1 also affects the behavior of potential entrants into market 2.¹⁰

The potential entrant B's decision whether to enter a market depends on its *total* profits there (how aggressively it plays once it is in depends on its marginal profit). The sign of the effect on B's total profits (if it enters) depends on whether A plays more or less aggressively in market 2 after the shock, that is, on the sign of (dS_2^A/dZ) . Result 2 above therefore shows that the sign of the effect on entry depends *only* on whether there are joint economies or diseconomies across the markets, and *not* on whether products are strategic substitutes or strategic complements.

The change in A's profits through the effect on entry into market 2 of a shock in market 1 is summarized below.

	Joint Economies	Joint Diseconomies
Strategic substitutes	+	-
Strategic complements	+	-

IV. Sequential Markets

The strategic effect is slightly different if A is able to precommit to its output in market 1 before A and B compete in market 2. In general, A will *not* set marginal revenue equal to marginal cost in market 1 when it considers the strategic effect.¹¹ The most obvious examples of

¹⁰ We model this formally as follows: (i) A is precommitted to competing in markets 1 and 2, (ii) there is a profitability shock in market 1, (iii) B decides on the basis of the shock whether or not to enter market 2, and (iv) the markets clear simultaneously.

¹¹ We are defining marginal revenue and marginal costs here in the usual way: $MR_i^F = \partial TR^F/\partial q_i^F$ and $MC_i^F = \partial TC^F/\partial q_i^F$, where MR , TR , MC , and TC represent marginal and total revenues and costs for firm F, and the subscript indexes markets. Thus the mar-

sequential markets are "learning curve" models, where there are joint economies so that increased production by A in period 1 (market 1) reduces its marginal costs in period 2 (market 2) and "natural resources" models where increased production in period 1 raises A's marginal costs in period 2.¹²

To consider the sequential case we need make only one modification in our formal model. The first equilibrium condition, instead of being $\partial\pi^A/\partial S_1^A = 0$, becomes $d\pi^A/dS_1^A = 0$. Firm A chooses its market 1 strategy taking into account its total effect on profits, including its influence on S_2^B . The implications of having sequential markets can be readily seen just from examining that first-order condition:

$$\frac{d\pi^A}{dS_1^A} = \frac{\partial\pi^A}{\partial S_1^A} + \frac{\partial\pi^A}{\partial S_2^B} \frac{dS_2^B}{dS_1^A} + \frac{\partial\pi^A}{\partial S_2^A} \frac{dS_2^A}{dS_1^A} + \frac{\partial\pi^A}{\partial Z} \frac{dZ}{dS_1^A} = 0. \quad (9)$$

We know from the second first-order condition, equation (2), that $\partial\pi^A/\partial S_2^A = 0$. Also $dZ/dS_1^A = 0$, so the total effect on profits of an increase in S_1^A is marginal revenue less marginal cost ($\partial\pi^A/\partial S_1^A$) plus a strategic term. The value of the strategic term $(\partial\pi^A/\partial S_2^B)(dS_2^B/dS_1^A)$ can be found by differentiating and solving the first-order equations (2) and (3) simultaneously, as before. $\partial\pi^A/\partial S_2^B$ is negative provided that products are (conventionally defined) substitutes so that the sign of the strategic term = $-\text{sign}(dS_2^B/dS_1^A) = -\text{sign}[(\partial^2\pi^A/\partial S_1^A \partial S_2^A) \cdot (\partial^2\pi^B/\partial S_2^B \partial S_2^A)]$.

With joint economies, as in the learning curve case, if there are strategic substitutes then the strategic term is positive so $\partial\pi^A/\partial S_1^A$ will be negative; that is, A will choose S_1^A at a higher level than the point where marginal revenue equals the marginal cost of increasing S_1^A . An obvious implication is that A may produce in market 1 even if total costs exceed total revenues in that market. The same results would hold with joint diseconomies and strategic complements.

If we had a negative strategic effect—joint diseconomies and strategic substitutes or joint economies and strategic complements—

ginal cost in market 1 is the long-run marginal cost and correctly anticipates market 2 output. We are considering a "perfect" Nash equilibrium of the game in which A precommits to S_1^A and then A and B simultaneously choose S_2^A and S_2^B . The equilibrium $(\bar{S}_1^A, \bar{S}_2^A, \bar{S}_2^B)$ is "perfect" in that $(\bar{S}_2^A, \bar{S}_2^B)$ is a Nash equilibrium of the single market game played in market 2, holding $S_1^A = \bar{S}_1^A$. We suppose that, for the matrix π , evaluated at $(\bar{S}_1^A, \bar{S}_2^A, \bar{S}_2^B)$ instead of $(\bar{S}_1^A, \bar{S}_2^A, \bar{S}_2^B)$, it is still the case that $\pi_{22}\pi_{33} > \pi_{23}\pi_{32}$. It follows that for S_1^A near \bar{S}_1^A we can solve uniquely for S_2^A and S_2^B near $(\bar{S}_2^A, \bar{S}_2^B)$. By the implicit function theorem we know that the functions $S_2^A(S_1^A)$ and $S_2^B(S_1^A)$ are differentiable when $S_1^A = \bar{S}_1^A$.

¹² More usually with sequential markets, both firms will be in both markets (i.e., in both periods). We consider the case in which only A is in market 1 in order to simplify the analysis. The qualitative effect that the existence of market 2 has on A's market 1 strategy is unaffected by the presence of B in market 1 (see Bulow et al. 1983).

the exact opposite results would hold. A firm may stay out of a market even though there are no fixed costs and marginal revenue exceeds marginal cost for the first few units. In the numerical example in Section II, firm A would have stayed out of market 1 if that market cleared prior to market 2.

Note that with sequential markets (but not simultaneous markets) a firm cannot be hurt by the existence of a profitable market that clears first. Because A precommits to a level of S_1^A , a small positive shock, ΔZ , will raise profits by exactly $q_1^A \Delta Z$. In sequential markets A may take an apparently unprofitable opportunity because of its strategic implications. This cannot happen in the simultaneous markets equilibrium because B anticipates that $\partial \pi^A / \partial S_1^A = 0$ and A cannot gain by doing otherwise.

Our analysis can readily be applied to any decision A might make at one time that would affect its marginal profitability at a later time. We can reinterpret S_1^A as any strategic variable that affects future marginal profitability. For example, S_1^A might be investment in sunk costs in period 1 that reduces marginal costs in period 2. Then with strategic substitutes the strategic effect of investment is to make B play less aggressively in period 2 so that A will overinvest in fixed costs. With strategic complements, however, A will *underinvest* in fixed costs. This contrasts with the qualitative implications of papers that focus exclusively on the use of "excess capacity" to deter entry. We continue this discussion in Section VIA.

Note again the distinction between the effect of A's actions on a potential competitor's entry decision and the effect on the aggressiveness of the competitor contingent on its entry. A greater investment by A in period 1 will cause it to produce more in market 2 and therefore lowers B's *total* profits, so that reductions in A's marginal costs always have the strategic benefit of making entry less profitable for B. However, if B regards the products as strategic complements then, contingent on deciding to enter, B will compete more aggressively the more A has invested.

V. Quantity versus Price Competition

Thus far we have modeled competition as the choice of an abstract strategic variable S . In this section we specialize our analysis to two familiar models of oligopolistic competition: homogeneous products quantity competition and differentiated products price competition.

A. Quantity Competition

In quantity competition firm i chooses $s_i = q_i$, the number of units to be sold in the market. If there are n firms, then (with undifferentiated

products) the market price is a function of industry quantity $f(\sum_{k=1}^n q_k)$, and firm i 's costs are $C_i(q_i)$. The condition for strategic complements is

$$\frac{\partial^2 \pi_i}{\partial q_i \partial q_j} = f' \left(\sum_{k=1}^n q_k \right) + q_i f'' \left(\sum_{k=1}^n q_k \right) > 0, \quad i \neq j. \quad (10)$$

We note that total revenues for the firm are $q_i f(\sum_{k=1}^n q_k)$. Thus the slope of firm i 's marginal revenue curve is

$$\frac{\partial^2 [q_i f(\sum_{k=1}^n q_k)]}{\partial q_i \partial q_i} = 2f' \left(\sum_{k=1}^n q_k \right) + q_i f'' \left(\sum_{k=1}^n q_k \right). \quad (11)$$

The difference between (10) and (11) is simply $f'(\sum_{k=1}^n q_k)$, the slope of the demand curve. Thus (10) can be rewritten as

(slope of marginal revenue curve) > (slope of demand curve) (10')

or that the demand curve is steeper than the marginal revenue curve. Of course with linear demand and quantity competition the firm always regards its marginal revenue curve as twice as steep as its demand curve and therefore regards the products as strategic substitutes.

If industry marginal revenue is decreasing in total output, then (with undifferentiated products) only a firm producing more than half the total market output can regard competitors' outputs as strategic complements.¹³ Thus, a large firm in an industry may regard products as strategic complements while its competitive fringe regards them as strategic substitutes (the reverse result is impossible). With a constant elasticity demand curve and a small enough fringe the dominant firm will always regard the products as strategic complements because its marginal revenue curve will be flatter than its demand curve. Consider the constant elasticity inverse demand $p = (\sum_{k=1}^n q_k)^{-\alpha}$, $0 < \alpha < 1$, at an equilibrium $\bar{q}_1, \bar{q}_2, \dots, \bar{q}_n$ in which $(\sum_{k \neq i} \bar{q}_k) / \bar{q}_i < \alpha$ —that is, firm i is the dominant firm and the other firms represent a sufficiently small fringe. The reader can calculate that firm i regards products as strategic complements ($\partial^2 \pi_i / \partial q_i \partial q_j > 0, j \neq i$) while all other firms regard the products as strategic substitutes.

This dominant firm result has two interesting applications. First, it provides a setting in which the dominant firm expands in response to a fringe incursion simply because the dominant firm is a Cournot-Nash player; we do not need to rely on asymmetric information or the

¹³ With undifferentiated products quantity competition, a firm will either regard all its competitors' products as strategic substitutes or regard all its competitors' products as strategic complements, because the firm's marginal revenue curve is only a function of competitors' combined output.

desire of the dominant firm to establish a "reputation" in repeated play. Second, the dominant firm can credibly build capacity that it will use if it is faced with competition even though the capacity will sit idle if the competition does not arise. The firm may thus hold excess capacity to deter entry, in contrast to Dixit (1980) and Spulber (1981); see Section VID.

B. Price Competition

We now consider the case where the strategic variables are prices,¹⁴ and first suppose there are constant marginal costs of production. If demand for B's product is downward sloping given a fixed price p^A for A's product, then at a profit-maximizing price B is setting $p^B[1 + (1/\eta)] = MR = MC$, where $\eta = \{[\partial q^B(p^A, p^B)]/\partial p^B\} (p^B/q^B)$ is B's elasticity of demand with respect to B's own output, given p^A . When A raises price (thus raising B's quantity), B will adjust so that this relation again holds. With constant marginal cost it is clear that whether B regards the products as strategic substitutes or complements depends strictly on elasticity—if demand becomes more inelastic when p^A is raised, then B will respond by raising p^B , and we have strategic complements. If B's demand becomes more elastic at the original p^B when A raises price, then B will respond by cutting p^B and we have strategic substitutes.

With increasing or decreasing marginal costs both sides of the $MR = MC$ equation are affected by A's price increase. With increasing marginal costs, even if elasticity is held constant A's price rise will cause B to raise price. With decreasing marginal costs and constant elasticity, B will cut price when A charges more (strategic substitutes). With demand of the form $q_2^B = f(p_2^A) + g(p_2^B)$, $f' > 0$, $g' < 0$, whether B regards the products as strategic substitutes or complements depends on whether its demand curve is steeper (strategic complements) or less steep (strategic substitutes) than its marginal cost curve. This condition determines whether the increase in B's quantity caused by a price increase by A decreases B's marginal revenue by more (strategic complements) or less (strategic substitutes) than it has changed marginal cost. With linear demand and increasing marginal cost, for example, B will always regard the goods as strategic complements.

¹⁴ By price competition we mean a game in which firms set prices and then must sell all that is demanded at that price. We describe below how price competition can be modeled within the framework of Sec. III: For firm A, let $\hat{\pi}^A(q_1^A, p_2^A, p_2^B) = R^A(q_1^A) + p_2^A f^A(p_2^A, p_2^B) - \bar{C}[q_1^A, f^A(p_2^A, p_2^B)]$, where f^A is the quantity A sells in market 2 when A and B charge prices p_2^A and p_2^B , respectively, and where \bar{C} is the technologically given cost function depending on the quantities q_1^A and $q_2^A = f^A(p_2^A, p_2^B)$. We can write $\hat{\pi}^A(S_1^A, S_2^A, S_2^B) = \hat{\pi}^A(S_1^A, 1/S_2^A, 1/S_2^B)$ and then employ our more general analysis.

VI. Applications

A. Strategic Underinvestment in Fixed Costs

As we noted in Section IV, selling units in one market in order to reduce marginal costs in a second market is formally equivalent to investing in capital that will directly lower the marginal production costs in the second market. With decreasing marginal costs a firm may sell units at a loss in the first market in order to prevent entry in the second, if the markets are sequential. This is equivalent to the familiar result that a firm may overinvest in capital in the first period of a 2-period game—that is, invest beyond the point where an extra dollar's investment in period 1 saves a dollar's expenses in period 2—in order to reduce its marginal cost and hence deter entry in the second period.¹⁵

If, however, the firm cannot prevent entry in the second period, then if we have decreasing costs and strategic complements the firm may *underinvest* in period 1—stop investing at a point where an extra dollar's investment would save more than a dollar's expenses in period 2—because with strategic complements the strategic effect of reducing marginal costs is to make opponents compete more aggressively in period 2.

Suppose that firm A produces output from a neoclassical, constant-returns-to-scale production function $q = f(K, L)$. Assume that A can install capital in period 1 at a price r and that in period 2 firm A can hire labor at price w and immediately produce output. In period 2 firm A and another firm B, with known marginal cost, compete by announcing quantities or prices S_2^A and S_2^B for the produced goods. If B regards the products as strategic substitutes ($\partial^2 \pi^B / \partial S_2^A \partial S_2^B < 0$), then A's equilibrium choice of \bar{K} and \bar{L} satisfies $\bar{K}/\bar{L} > \text{efficient } K/L$, so there is "overinvestment," but if B regards the products as strategic complements, then $\bar{K}/\bar{L} < \text{efficient } K/L$, and there is underinvestment.

Thus, for example, with price competition and linear demand, the more a firm invests, the lower an entrant's price will be, because greater investment lowers the incumbent's expected price. A firm may have an "entry deterrence" incentive to overinvest, but if it cannot deter entry then it has a "price war avoidance" incentive to hold back and underinvest. Similarly, if transportation firms compete on

¹⁵ It may be possible for the firm to increase investment and lower total variable cost but still raise marginal cost in the relevant range. This would reverse all the results in this section; e.g., such investment would make potential entrants assume that the firm would compete less aggressively and would encourage potential entry, so that the firm would have an incentive to underinvest to deter entry.

the quality of their facilities, then "raising the stakes" by investing in expensive modern equipment may make entry less likely, but if entry does occur (and the firms' products are strategic complements), the entrant may buy more modern equipment as well. A firm that cannot deter entry may underinvest.

These results contrast with the work of Spence (1977), Dixit (1979, 1980), and others, who focus exclusively on the use of excess capacity to deter entry.

B. Royalties and License Fees

Kamien and Tauman (1983) have studied the problem of an inventor who is selling the rights to a technology that would shift downward the marginal cost curve of the licensees in an oligopolistic industry. Would the inventor earn more money by charging each firm a royalty per unit produced or a fixed fee per firm?

With strategic substitutes firms will pay more than the direct savings to obtain a lower marginal cost, because their lower costs will cause competitors to compete less aggressively. The inventor is better off charging a flat fee because his customers will pay a premium for low marginal costs. With strategic complements, however, lower marginal costs for a firm cause its competitors to adopt more aggressive strategies so that licensees will bid less than their direct saving for the use of the innovation. In this case the inventor can eliminate the harmful strategic effect by charging a royalty fee equal to the per unit savings in production, so that firms' marginal costs are unaffected by the innovation.

C. Dumping in International Trade

The broadest definition of dumping includes any case where a firm price discriminates between two markets. A narrower definition, and the one that concerns us, covers situations in which a firm sells in a market to a point where marginal revenue is less than marginal cost. The strategic effect provides two explanations of dumping.

First, if a firm is selling only in a foreign market, and if the strategic variables are strategic substitutes, then a subsidy to the firm will increase its profits by more than the subsidy. Thus a government may subsidize a firm to "dump" its products at low prices in a foreign market.¹⁶ Similarly, with joint diseconomies and strategic substitutes there are strategic reasons to impose a tax (such as a rebatable VAT)

¹⁶ This point has also been made independently by Eaton and Grossman (1983), Brander and Spencer (1984), Dixit (1984), and Krugman (1984).

on domestic sales of a domestic monopolist but not on exports, rather than charge a lower tax on all production. These strategic benefits may exceed the welfare loss resulting from reduced domestic sales.¹⁷

Second, in sequential markets firms may produce unprofitably in one period to gain the strategic benefit of making competitors less aggressive in future periods. For example, if a Japanese firm has decreasing costs over time (as in an industry with a "learning curve") and its American competitor's product is a strategic substitute, the firm may "dump" output in the early stages of a market's development to encourage the competitor to either contract operations or withdraw from the market.

D. Holding Idle Capacity to Deter Entry

Building extra capacity converts marginal costs into fixed costs and so raises a firm's output. Therefore, such actions may deter entry. However, beyond a certain point additional capacity will not deter entry further. Capacity deters competitors only if they believe the capacity will be used after entry. Thus the most extra capacity a firm will build is the amount it will actually use if entry occurs. Dixit (1980) and Spulber (1981) (effectively assuming strategic substitutes) concluded that if it would be profitable to use all capacity after competition enters, then it surely would be profitable to use all capacity if no entry occurs. Hence no capacity would be built and subsequently left idle.

With strategic complements and quantity competition, however, a firm will want to supply less if it remains a monopolist than if competitors produce. Consequently, capacity can be built that the firm could credibly threaten to use in the event of entry but that would be left idle if entry was deterred. Firms anticipating price competition with strategic complements may also rationally install idle capacity to deter entry. We give further details in Bulow, Geanakoplos, and Klemperer (1985).

E. Is a Little Bit of Competition a Good Thing?

In this section we restrict ourselves to quantity competition in homogeneous products. Consider an entrant into a monopoly market, where the entrant has constant marginal costs just below the pre-entry

¹⁷ The policy, tax or subsidy, on the (home sales, exports) of a domestic monopolist that maximizes the value of the strategic effect is as follows:

	Joint Economies	Joint Diseconomies
Strategic substitutes	(Subsidy, subsidy)	(Tax, subsidy)
Strategic complements	(Tax, tax)	(Subsidy, tax)

monopoly price. Does this "little bit of competition" increase or decrease welfare?

Entry is a good thing with strategic complements and is welfare reducing with strategic substitutes. Because the entrant produces a small amount at a cost almost equal to the social value of its output, the entrant has only a second-order direct effect on welfare. However, the entry will cause changes in the incumbent's output, and those changes do have a first-order effect on surplus, equal to the change in the incumbent's output times the price minus its marginal cost. With strategic complements the incumbent responds to entry by increasing output (and thus welfare); with strategic substitutes the incumbent's output, and thus welfare, is decreased.

F. Rational Retaliation as a Barrier to Entry

A special case of entry deterrence occurs when two monopolists are potential entrants into each other's markets. It may be rational for a firm A to retaliate against entry into its market by a second firm B but not enter against B otherwise.

There are two reasons. First, if B faces diseconomies of scope its expansion into a second market makes it generally more vulnerable to entry. Second, B's entry will change A's equilibrium output in the market where it is the incumbent and therefore possibly alter its decision of whether to enter B's market. For example, if there are joint diseconomies across markets, then an attack that reduced A's home market output would also raise the marginal profitability of its producing in B's market.

The story that one firm might do best to avoid another's "territory" for fear of retaliation is not unfamiliar. The point we are making here is that neither does the equilibrium in which each company avoids the other's territory depend on tacit collusion, nor is the threat of retaliation one that would be costly to carry out. Initially, it might be costly for A to enter B's market even if it were not worried about retaliation itself. Thus no tacit collusion is necessary to restrain it from expanding. However, if B enters A's market then it may be profitable for A to retaliate. So the threat that deters B's expansion is a *credible* one.¹⁸

¹⁸ The precise game we are describing has three stages: First B announces whether it will enter A's market, then A announces whether it will enter B's market, then the simultaneous market game is played. We consider only perfect equilibria. The first reason for retaliation, that B's higher marginal costs make its market more attractive to potential entrants, was discussed in the latter part of Sec. III. The second reason, that even if B's marginal costs are unaffected A finds entering B's market more attractive, is illustrated by the following numerical example:

A is initially a monopolist in market 1; B is the incumbent monopolist in market 2. Each firm faces a fixed cost of 750 of competing in each market. The inverse demand in

G. *Limit Overpricing*

The limit-pricing literature suggests that a monopolist may price lower than the pre-entry profit-maximizing price in order to signal low costs and deter entry (see, e.g., Milgrom and Roberts 1982). However, an important assumption in this literature is that any entrant learns the incumbent's costs immediately after entry. If this assumption is relaxed, then, if entry occurs and with strategic complements, the incumbent would like the entrant to believe that its costs are higher than they really are. Thus the incumbent might, in principle, charge a higher first-period price than the monopoly price. Although it has an "entry deterrence" incentive to price low and signal low costs, it has a "price war avoidance" incentive to price high and signal high costs, which helps it if entry does occur. Again the basic point is that with strategic complements a firm's competitors play less aggressively if the firm's costs are perceived to be higher.

H. *The Learning Curve*

The learning curve literature discusses the problem of firms that compete in sequential markets and experience joint economies. An important issue is whether the sequential (or closed loop) equilibrium in such a game is much different from the simultaneous (open loop) equilibrium in which firms ignore the impact of their first-period decisions on competitors' second-period strategies.

In his seminal paper, Spence (1981) compared the simultaneous and sequential equilibria in a two-period problem with two firms producing in each period in which industry demand had a constant elasticity of -1.25 and there was no spillover or diffusion of knowledge between firms. He concluded that, while firms' first-period outputs would be greater in the sequential case, the differences from the

market i is $p_i = 100 - q_i^A - q_i^B$. Firm B can supply all its markets as much as it wants at a constant marginal cost of zero. Firm A has the capacity to produce 60 units at a constant marginal cost of zero but has a very high marginal cost (say 100) of supplying additional units beyond 60. If A and B stay in their respective markets, each will produce 50 units and sell at a price of 50, earning net profits of $50 \times 50 - 750 = 1,750$ each. A initially has no incentive to invade B's market. If it did, B would produce 40 in the contested market. A would produce 20 in the contested market and 40 in the uncontested market, earning 1,700. If, however, B enters A's market, A has the choice of remaining in its home market only and selling 33% for a net profit of 361%, or retaliating by entering B's market. If both firms are in both markets, the equilibrium is that B produces 35 in each market (at a price of 35) and A produces 30 in each. B's profits are 950 and A's profits are 600. Thus A would react to B's entry by entering B's market but would not have entered otherwise. B, which apparently had an incentive to invade A's market (its profits would have risen from 1,750 to 2,111% if A had not retaliated), would have done better to confine itself to one market.

simultaneous case (which is much easier to solve in many-period models) were very small. Fudenberg and Tirole (1983), analyzing linear demand, achieved the same qualitative result as Spence but argued that the differences in the equilibria between the simultaneous and sequential analyses were important. By discussing the interrelationship of markets through strategic substitutes and complements, we can clarify this issue.

Spence's small quantitative differences in equilibria were an artifact of his choosing a constant elasticity demand curve with elasticity near -1 . The reader can confirm that with constant elasticity of -1 (only necessary for the second period) and symmetrical duopoly quantity competition, $\partial^2 \pi^A / \partial S_2^A \partial S_2^B = \partial^2 \pi^B / \partial S_2^B \partial S_2^A = 0$, so the strategic term is neutral. In this case there will be no difference between the simultaneous and sequential solutions.

With linear demand and quantity competition, products are strategic substitutes and first-period output is higher in the sequential game. However, there is no reason to assume that a real market with quantity competition would exhibit strategic substitutability. Strategic complementarity gives all decreasing cost firms the incentive to produce less in the sequential equilibrium, reversing the results of Spence (1981) and Fudenberg and Tirole (1983).

With two firms in two markets and price competition, the situation is more complicated.¹⁹ Firm A's price in the first period not only affects its own costs in the second period but, by affecting B's first-period sales, affects B's second-period costs. (In quantity competition A's choice of quantity does not affect B's first-period quantity and so cannot affect B's second-period costs.)²⁰ In calculating the strategic effect of its action in the first period, A must consider its impact on B's second-period reaction curve as well as on A's. Strategic substitutes price competition will always give lower first-period prices in the sequential equilibrium than in the simultaneous equilibrium. Strategic complements price competition can lead to either higher or lower first-period prices in a sequential equilibrium than in a simultaneous equilibrium. However, with linear demand and symmetrical firms, a lower price for A in period 1 will always imply a *higher* price for B in period 2 (because of B's higher costs), and because of this favorable strategic effect firms will charge a lower price (and so produce more) in the sequential equilibrium. Also, Fudenberg and Tirole (1985)

¹⁹ We analyze this case precisely in Bulow et al. (1983).

²⁰ An exception is when the learning curve has "spillovers" so that diffusion of knowledge allows all firms to learn from any one firm's production. (Lieberman [1982] gives empirical evidence for the importance of spillovers.) We discuss this case further in Bulow et al. (1983).

show that with price competition in a spatial location model, learning by doing still gives firms a strategic incentive to produce more.

I. Natural Resource Markets

Natural resource models are the mirror image of learning curve models: They are games played over time (i.e., sequentially) where greater output in period 1 will increase marginal cost in period 2. That is, firms' production costs will generally rise with cumulative output as "digging deeper" is required for extraction. In this case, with strategic substitutes, a natural resource oligopolist will produce less in the first period and more in the second than if both periods' strategic variables were chosen simultaneously, because of the negative strategic effect. With strategic complements the firms will produce beyond the point where $MR = MC$ in the first period because of the positive strategic effect.

Bulow and Geanakoplos (1983) show that with strategic substitutes a firm may choose to produce some high-priced "backstop" reserves in the first period, even if some cheaper reserves that will never be used are available for the purpose. The reason is that the strategic benefit of leaving cheap reserves in the ground and lowering second-period marginal costs exceeds the cost of producing inefficiently.

J. Product Portfolio Selection

The most obvious application of our results is to the theory of how a firm should select a "portfolio" of businesses in which to compete. The strategic effect on an old market of producing in a new market must be considered.

As a possible example of a firm that ignored the strategic effect of diversification, consider the case of Frontier Airlines. In the early 1980s the firm expanded beyond its original Denver hub to capitalize on some apparently profitable opportunities. Many feel the airline made a tactical error. After Frontier spread itself over several new markets, other airlines began to compete much more aggressively for shares of the Denver market. Some of this new competition may have been inevitable in a changing, deregulated environment, but some of it was probably due to a perceived weakness on Frontier's part that arose from its being "spread thin."²¹

²¹ See "Where Frontier Lost Its Way," *Business Week*, February 7, 1983, p. 120.

K. Markets Where Demands, Rather than Costs, Are Interrelated

Throughout our analysis we assumed that demands across markets were independent so that the term $\partial^2 \pi^A / \partial S_1^A \partial S_2^A$ depended solely on whether A had joint economies or diseconomies in production. We could just as easily have assumed that demands were interrelated.²² With independent costs, $\partial^2 \pi^A / \partial S_1^A \partial S_2^A$ is positive if a firm's demand in one market is complementary to its demand in the second (equivalent on the cost side to joint economies) and would be negative if selling more in one market hurts prospects in the other. Firms must consider the cross-effects in making marginal revenue calculations and consider the strategic effects of their actions in one market on competitors' actions in a second.²³

VII. Conclusion

This research began as an investigation into how a change in one market can have ramifications in a second market, even if the demands in the two markets are unrelated. We found that a critical issue in determining the nature of the interaction was whether competitors regarded products as strategic substitutes or strategic complements. In other words, would a more aggressive strategy by one firm in a market elicit an aggressive response from its competitors, or would an aggressive move be met with accommodation (competitors playing less aggressively than previously)?

This same distinction turns out to be critical in many other oligopoly models. Whether firms overinvest or underinvest in capital relative to the efficient level for production, whether innovations are most profitably sold for fixed fees or licensed for royalties, whether governments maximize national income by taxing or by subsidizing exports, whether firms have incentive to diversify into apparently unprofitable markets or to shun apparently profitable opportunities, and whether firms produce more or less when markets operate simultaneously than when they operate sequentially, all depend on whether

²² See, e.g., Judd (1983), who analyzes how selling goods that are substitutes affects a multiproduct firm's ability to deter entry, and Klemperer (1984), who examines markets in which consumers' costs of switching between brands of a product make it easier for a firm to sell to consumers who purchased from it in a previous period (market). Other examples of markets with interrelated demands are the market for children's television shows and the toy market, and the markets for small and mid-sized cars.

²³ If demands are connected, firms must of course also account for any direct effects of their actions in one market on competitors' behavior in another market.

competition is with strategic substitutes or with strategic complements.

We cannot determine whether products are strategic substitutes or strategic complements without empirically analyzing a market. Both modes of competition are compatible with both price and quantity competition. In the case of quantity competition, the mode of competition depends only on the market demand. With price competition, strategic substitutes competition is most likely with increasing marginal costs and least likely with decreasing marginal costs, but the shape of the demand curve is again critical. Thus assumptions that are innocuous in most models of monopoly and atomistic competition, for example, whether demand is locally linear or of constant elasticity, are of crucial importance in the oligopoly context. If an oligopoly model assumes, say, linear demand and quantity competition, the real economic assumption may be that products are strategic substitutes. A local change in the curvature of demand might give strategic complements and reverse the results.

It has long been suspected that any result in oligopoly theory, or its converse, can be generated by an appropriate choice of assumptions. Strategic substitutes and complements help explain this basic ambiguity and so focus on a critical distinction. When thinking about oligopoly markets the crucial question may *not* be, Do these markets exhibit price competition or quantity competition or competition using some other strategic variable? but rather, Do competitors think of the products as strategic substitutes or as strategic complements?

References

- Baldani, Jeffrey P. "Strategic Advertising and Credible Entry Deterrence Policies." Mimeographed. Hamilton, N.Y.: Colgate Univ., 1983.
- Brander, James A., and Spencer, B. J. "Tariff Protection and Imperfect Competition." In *Monopolistic Competition and International Trade*, edited by Henryk Kierzkowski. Oxford: Oxford Univ. Press, 1984.
- Bulow, Jeremy I., and Geanakoplos, John D. "Strategic Resource Extraction: When Easy Doesn't Do It." Mimeographed. Stanford, Calif.: Stanford Univ., May 1983.
- Bulow, Jeremy I.; Geanakoplos, John D.; and Klemperer, Paul D. "Multimarket Oligopoly." Research Paper no. 696. Stanford, Calif.: Stanford Univ., Grad. School Bus., 1983.
- . "Holding Idle Capacity to Deter Entry." *Econ. J.* 95 (March 1985): 178–82.
- Dixit, Avinash K. "A Model of Duopoly Suggesting a Theory of Entry Barriers." *Bell J. Econ.* 10 (Spring 1979): 20–32.
- . "The Role of Investment in Entry-Deterrence." *Econ. J.* 90 (March 1980): 95–106.
- . "International Trade Policy for Oligopolistic Industries." *Econ. J.* 94 (suppl. 1984): 1–16.

- Eaton, Jonathan, and Grossman, Gene M. "Optimal Trade and Industrial Policy under Oligopoly." Working Paper no. 1236. Cambridge, Mass.: N.B.E.R., November 1983.
- Fudenberg, Drew, and Tirole, Jean. "Learning-by-Doing and Market Performance." *Bell J. Econ.* 14 (Autumn 1983): 522-30.
- . "Dynamic Models of Oligopoly." In *Fundamentals of Pure and Applied Economics*, edited by Jacques Lesourne and Hugo Sonnenschein. Paris: Harwood, forthcoming, 1985.
- . "The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look." *A.E.R. Papers and Proc.* 74 (May 1984): 361-66.
- Judd, Kenneth L. "Credible Spatial Preemption." Discussion Paper no. 597. Evanston, Ill.: Northwestern Univ., Grad. School Management, 1983.
- Kamien, Morton I., and Tauman, Yair. "Fees versus Royalties and the Private Value of a Patent." Discussion Paper. Evanston, Ill.: Northwestern Univ., Center Math. Studies Econ. and Management Sci., 1983.
- Klemperer, Paul D. "Switching Costs and Dynamic Oligopoly Pricing." Mimeographed. Stanford, Calif.: Stanford Univ., 1984.
- Krugman, Paul R. "Import Protection as Export Promotion: International Competition in the Presence of Oligopoly and Economies of Scale." In *Monopolistic Competition and International Trade*, edited by Henryk Kierzkowski. Oxford: Oxford Univ. Press, 1984.
- Lieberman, M. "The Learning Curve, Pricing, and Market Structure in the Chemical Processing Industries." Ph.D. dissertation, Harvard Univ., 1982.
- Milgrom, Paul, and Roberts, John. "Limit Pricing and Entry under Incomplete Information: An Equilibrium Analysis." *Econometrica* 50 (March 1982): 443-59.
- Schmalensee, Richard. "Advertising and Entry Deterrence: An Exploratory Model." *J.P.E.* 91 (August 1983): 636-53.
- Spence, A. Michael. "Entry, Capacity, Investment and Oligopolistic Pricing." *Bell J. Econ.* 8 (Autumn 1977): 534-44.
- . "The Learning Curve and Competition." *Bell J. Econ.* 12 (Spring 1981): 49-70.
- Spulber, Daniel F. "Capacity, Output, and Sequential Entry." *A.E.R.* 71 (June 1981): 503-14.