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EFFICIENCY GAINS FROM STRATEGIC INVESTMENT

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INTRODUCTION

AS recognized in literature on the dynamics of competition, many aspects of industry behavior appear to be inconsistent with short run profit maximization. In particular: Firms may be observed to operate well below capacity for extended periods. Examples abound of capital investments being made far in advance of actual need. Large investments in brand name promotion and product differentiation are characteristic of some industries. Others are characterized by very aggressive investments in innovation.

Beyond the actual investment, there appears to be a concerted effort to inform competitors and others that such investments have been made. Industry trade journals and the financial press frequently carry announcements of planned expansion and of innovation based on press releases supplied by the firms.

A recent literature (Williamson [14], Wenders [12], Spence [9] and [10], Dixit [5] and [6]) explains these practices as strategic decisions by firms in an effort to maximize long run profits by restricting competition. Investment by existing industry members is argued to deter entry by potential competitors. The emerging view, based on this literature, is that strategic entry deterrence is a new form of barrier to entry and tends further to strengthen the market power of insiders. An important implication of this view is that potential competition would be insufficient to insure competitive prices and outputs. This is in sharp contrast to the positions of Demsetz [3] and Brozen [2], both of whom have argued that potential competition is all that is necessary for competitive output.

This paper presents an alternative view of strategic behavior which is consistent with enhanced market efficiency. The basic result stems from the recognition that when exit is costly and information about competitors' investment expenditures is costly or nonexistent, then firm investments may be *ex ante* inefficient. Because of this, firms may achieve gains from engaging in complex signaling strategies which, of necessity, involve the making of strategic investments. In markets where potential competition is an effective constraint on pricing, the result is an unambiguous saving of real resources.

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II. THE SUPPLY COORDINATION HYPOTHESIS

In order to establish the validity of the assertion that strategic behavior can result in improved resource allocation it is convenient to focus on one form of strategic investment, capacity expansion, and then to generalize to other avenues for strategic behavior.

To begin the analysis it is useful to recognize that there is no need for strategic behavior in a rivalrously competitive industry that is not growing (and not innovating). The fixed costs of the (statistically) optimal technology are sufficient to discourage new investment by either existing firms or prospective entrants. The existence of fixed costs implies that exit is costly. Prospective entrants would realize this and would not invest. The result is that suppliers know who they are and hence the market functions smoothly – without supply side surprises. This is very much like having a property right to supply the market (though not a monopolistic one because of the threat provided by potential competition).

In Figure 1, the no growth situation is represented by demand curve D_1 with competitive price P_1 and output Q_1. Price is equal to long run average cost, and short run variable cost (SAVC) is represented by a dashed line. S_1 is a short run supply constraint based on capacity. The prospective entrant recognizes that unless he can charge a price below SAVC, the shut down point of existing industry members, they will not exit. With no growth and no innovation, entry is effectively deterred even without strategic investment.

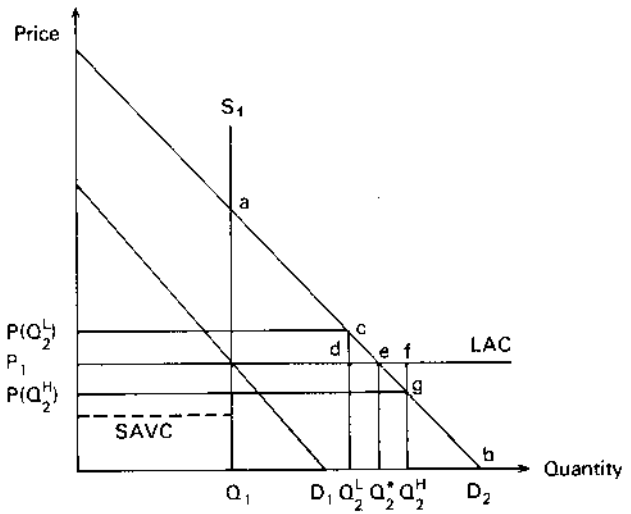

FIGURE 1.
Representation of the Supply Coordination Problem

Purposeful investment-signaling strategies arise in response to market growth. Market growth creates a residual demand and, in the absence of

organized markets for rights to expand capacity, it is not clear who will supply the residual. Firms compete for the right by investment in new capacity. In this competition by investment there is a potential for mistakes in the sense that too much or too little new capacity is supplied relative to expected demand.

Returning to Figure 1, demand growth is represented by a shift to D_2. The shift creates residual demand of ab. The surplus maximizing level of output to supply this is Q_2^* but it is conceivable that actual new capacity would produce too low a level of output (Q_2^L) or too high an output (Q_2^H). The effects of these capacity investment errors on price are evident in the figure. Note that the errors may occur even though the position of D_2 is known with certainty to all prospective investors in capacity.

Such mistakes result from what will be referred to as a supply coordination problem. Any firm's investment decision requires that it make a forecast of competitors' plans. Will they expand or not, and by how much? Wrong forecasts of competitors' planned capacity additions result in *ex ante* under- or over-capacity for the industry.

The possibility of *ex post* under- or over-capacity due to unpredicted demand shifts is ignored by assuming the new demand curve to be known to all suppliers with certainty. The decision to ignore demand uncertainty is not because it is unimportant, just that (aside from sharing forecast information) coordination activities of suppliers can do nothing to reduce demand uncertainty. This distinction from supply uncertainty is important since coordination resulting from demand uncertainty would typically involve some type of price fixing (e.g., to prevent "ruinous" competition) which contributes nothing to solving the underlying problem. Conversely, exchanging information about capacity expansion plans can have the desirable consequence of improving resource allocation.

Capacity adjustment is unlike most textbook markets in that there is no market mechanism—no invisible hand—to insure that the correct amount will be supplied in the short run. Supply may double or may not grow at all when what is actually called for is a 25 percent increase in capacity.

This is essentially a problem in information failure and there is an exact analogy for demand coordination. An example would be a movie theatre. Prospective viewers of a movie may know the supply of seats available with certainty, but (even if the ticket price is correctly set to maximize profit given expected demand) there is no mechanism to insure that the correct number of people will arrive for any given screening. To assure themselves seats, some people will arrive too early—wasting time. Others may arrive too late — wasting the trip if the show sells out. The problem arises not because the price is wrong *ex ante*, but because the behavior of individual demanders cannot be perfectly predicted. Demanders of the movie make incorrect forecasts about the actions of other demanders and the result is demand coordination failure. The obvious solution in this case is strategic (preemptive) purchases of tickets, i.e., reservations.

Accordingly, what is meant by supply coordination failure is that *planned* aggregate supply is wrong due to forecast errors of competitors' capacity investments. The basic point is that strategic investment may occur to reduce the likelihood and cost of supply coordination failure. Problems of demand uncertainty cannot be solved by strategic investment on the part of the supplier except for some very short run strategies such as producing buffer stocks.

As with any market failure, the cost of coordination failure is a deadweight loss. In Figure 1 the losses from under- and over-capacity are represented by triangles cde and efg respectively.

For firms, the risk of over- or under-capacity, with the concomitant effects on short run profits, may also raise the firm's cost of capital, which means that the value of the firm (other things equal) is reduced. A similar argument is made by Dewey [4] in which risk is included in the firm's utility function. He argues that collusion to reduce risk (even price variability due to uncertain demand) may be economically desirable.

The cost of supply coordination failure is resource misallocation relative to what would result from improved forecasts of aggregate supply and relative to what would result from the effects of lower risk on the cost of investment capital. These costs arise because *ex post* adjustment is costly. There is no free exit and expansion takes time. It should, therefore, be expected that resources will be expended to reduce the expected cost of supply coordination failure.

To summarize the basic argument, the cause of supply coordination failure is wrong forecasts of planned aggregate supply. In this context, strategic investment improves the ability of firms to forecast. It does this by converting simultaneous decisions into sequential ones. A firm that decides to expand announces its intent and this influences the decisions of other firms.

There are obvious problems. If all that were necessary is an announcement of intent then firms would benefit by lying about their plans – making false reservations just in case. Also, if an announcement were made too far in advance the announcement might just cause other firms to speed up their own activities.

What is required is that the firm making the announcement provide some evidence of an irreversible commitment or an insurmountable lead. There are several means by which this can be accomplished and relative costs will determine which mechanism is actually used.

As an information problem, supply coordination is plagued with the familiar problem of private production of information. Because of the public good or positive externality nature of information about investment plans, the information necessary to improve coordination will tend to be under-produced. In the extreme, private production will occur only if some way to privatize the benefits can be found.

III. STRATEGIC VERSUS NONSTRATEGIC INVESTMENT IN COMPETITIVE MARKETS

To establish more formally the basic thesis that strategic investment can result purely from the cost reducing efforts of rivalrously competitive firms, a simple investment project valuation model can be employed. The purpose of this analysis is to contrast the expected present value of a project that is undertaken without strategic investment to the expected value of the same project involving the use of a strategic signaling investment.

Consider an industry with growing demand. For simplicity we assume that the increased demand is sufficient to accommodate the output of one new plant, but that any of three outcomes is possible: the level of investment is correct (one firm invests), the level is too low (no investment is made) or the level is too high (two firms invest simultaneously). While other outcomes are possible, the added complexity contributes little to the analysis. Throughout the analysis each firm is regarded as operating a single plant. The existence of multiplant firms adds another dimension to the problem which will be taken up later.

The case of no investment can be dispensed with easily. A firm which invests nothing receives nothing even though the result (under-capacity) may be favorable for firms already in the industry. From the perspective of the firm contemplating investment in the project the case of no investment may be dropped from the analysis. Hence, four basic situations must be considered: the firm invests either strategically or nonstrategically, and the total number of similar investments is either one or two.

Let the nonstrategic capacity investment alternative be represented as a point-input point-output program. The net present value of the program conditional on no other firm simultaneously making a similar investment is

$$(V_o \mid N = 1) = -I_t e^{-rt} + X_n e^{-rn} \tag{1}$$

In (1) V_o is the expected net value of the project at time zero, N is the number of firms simultaneously investing I at time t to gain an expected return of X at time n. The discount rate, r, reflects project specific risk related to the actual level of X.

For convenience it is assumed that industry demand and cost functions are such that (conditional on no simultaneous entry) there is a unique optimal time, n, to begin production such that the time n value of X (total revenue less variable cost) is maximized subject to a competition constraint. The nature of the constraint is that given one firm's investment of I, no second firm will find it profitable to enter until further growth in industry demand would accommodate another (similar) investment.

By way of background, it may be assumed that the present value of I also depends on time, and the exact value of I_t in (1) represents the single best nonstrategic program out of a feasible set of nonstrategic programs, the one that minimizes the size of X_n sufficient to induce investment.

The purpose here is to establish the possible existence of a *strategic* investment plan that would reduce the required X_n relative to the best nonstrategic alternative and to examine the properties of the strategic alternative. To do this it is first necessary to develop an expression for V_o which is not conditional on N.

In the event that simultaneous nonstrategic investments do occur, two contingencies must be considered. Depending on the price-depressing effect of excess industry capacity relative to average variable cost, one or another of the firms may choose to shut down production. Alternatively all firms may elect to continue to operate with industry excess capacity, incurring both lower product prices and a higher average variable cost of production. (Clearly some other intermediate outcomes such as a temporary shutdown are also possible). The expected consequence of these contingencies to a given firm can be represented by a probability weighting function, $\alpha = \phi_0 \cdot (0) + \phi_\theta \cdot (\theta) + \phi_1 \cdot (1)$ where ϕ_0 is the probability that the firm shuts down, ϕ_1 is the probability that some other firm shuts down and ϕ_θ is the probability that all firms continue to operate. If the firm shuts down, its share of X_n is zero, if another firm shuts down, its share is one, if no firm shuts down it receives a θ share of X_n where θ incorporates the full impact of excess capacity. Hence the expected value of the project conditional on simultaneous investment by two firms can be stated as

$$(V_o | N = 2) = -I_t e^{-rt} + \alpha X_n e^{-rn} \tag{2}$$

Based on the above discussion $0 \leqslant \alpha \leqslant 1$.

The unconditional nonstrategic project valuation expression follows directly.

$$V_0 = -I_t e^{-rt} + pX_n e^{-rn} + (1-p)\alpha X_n e^{-rn} \tag{3}$$

where p is the probability of no simultaneous entry. V_0 is constrained to be less than or equal to zero by competition.

The existence of a strategic program which is more profitable than (3) is easily established using a two point-input point-output valuation model. Let S be a signaling investment such that if S is invested non-simultaneously with similar investment by other firms, the firm gains the right to invest I and collect X_n without the threat of simultaneous entry. If two firms invest simultaneously they are presumed to recognize they are playing a negative sum game and will determine a course of action accordingly. Again, several contingencies are possible. One or the other may decide to abandon the project (particularly if it is apparent to both that one has succeeded in producing a stronger claim on the project returns by the investment of S), or both may decide to proceed with completion of the projection. This process could be formalized as involving a hierarchy of investment signals (Ss of different sizes at different times for example).

The strategic valuation, conditional on no other firm entering is

$$(V'_0 | N = 1) = -S_t e^{-rt} - (I_t - \gamma S_t) e^{-rt} + X_n e^{-rn} \tag{4}$$

Expression (4) is analogous to expression (1) except for the strategic investment of S at time i. The expression provides for the contingency that investment of S may reduce the necessary investment at time t by some function (γ) of S.

Subtracting (1) and (4) to determine when the nonstrategic alternative would be preferred conditional on no simultaneous investment gives

$$(V'_0 - V_0 | N = 1) = -S_i e^{-ri} + \gamma S_t e^{-rt} \tag{5}$$

Only if $\gamma > 1$ is (5) positive and the strategic alternative preferred, but in this case (4) becomes (by definition) the preferred *nonstrategic* alternative intended to be represented by (1) in the first place. Thus γ is appropriately constrained such that $0 < \gamma < 1$. It follows that conditional on no simultaneous entry there is no strategic alternative that will be preferred to (1). In fact, strategic alternatives will generally be inferior. It is in those cases where $\gamma < 1$ that the benefit from strategic investment must be established.

The valuation expression conditional on simultaneous strategic investment is analogous to expression (2)

$$(V'_1 | N = 2) = -S_i e^{-ri} - \beta(I_t - \gamma S_t)e^{-rt} + \beta X_n e^{-rn} \tag{6}$$

Where β is a parameter similar to α in (2). If $\beta = 0$ (6) reduces to $-S_i e^{-ri}$, whereas if $\alpha = 0$ (2) reduces to $-I_t e^{-rt}$. Hence, since $S_i e^{-ri} < I_t e^{-rt}$ there are conceivable cases where $V'_0 > V_0$ even if firms should happen to invest S simultaneously.

Subtracting (2) from (6) gives

$$(V'_0 - V_0 | N = 2) = -S_i e^{-ri} + (1-\beta) I_t e^{-rt} + \beta\gamma S_t e^{-rt} + (\beta - \alpha) X_n e^{-rn} \tag{7}$$

which describes the potential advantage of strategic over nonstrategic investment conditional on simultaneous investment in the signal.

The unconditional strategic project valuation expression follows from (4) and (6)

$$V'_0 = -S_i e^{-ri} - (p + (1-p)\beta)(I_t e^{-rt} - \gamma S_t e^{-rt} - X_n e^{-rn}) \tag{8}$$

and the unconditional difference between the strategic program (8) and the nonstrategic program (3) is

$$(V'_0 - V_0) = -S_i e^{-ri} + I_t e^{-rt} - (p + (1-p)\beta)(I_t - \gamma S_t)e^{-rt} + (1-p)(\beta - \alpha) X_n e^{-rn} \tag{9}$$

Above discussion has demonstrated the possible existence of positive values for (9). The implication is that strategic investment programs may be preferred to nonstrategic ones purely on the basis of lower present valued cost. The level of X necessary to cover the cost of investment is reduced by the strategic program, hence competitive pressures alone could dictate such strategic

practices as preemptive investment, excess capacity, preemptive advertising and preemptive innovation.

It is conceivable that the signal investment, S, may actually be chosen from a set of possible alternative signal investments. It can be easily shown that firms will elect to use the form of signaling investment that is least costly, other things equal. Assuming $S_t = S_i e^{r(t-1)}$, the derivative of (9) with respect to S is

$$(V'_0 - V_0)_s = (-1 + p\gamma + B\gamma - p\beta\gamma)e^{-ri} \tag{10}$$
$$= [-p(1-\gamma) - (1-p)(1-\beta\gamma)]e^{-ri}$$

In the second form with p, γ and β all appropriately constrained to lie between zero and one it is clear that (10) is negative. The value of $V'_0 - V_0$ increases as the cost of the signal falls.

The above demonstrated possibility for gain from strategic investment results purely from the potential for a real resource saving in the event of simultaneous investment of S. A further advantage arises, *a fortiori*, if firms are risk averse. After investment of S the question of whether (4) or (6) represents the true outcome will be known with certainty. In addition, if simultaneous investment of S does occur, the value of β may be known with certainty. Because of the sequential decision process of the strategic alternative the interest rate used to discount the flows other than S_i in (8) may be lower. Since the inflows are presumed to occur after the outflows this implicitly increases V'_0 relative to V_0.

IV. EVIDENCE OF CONCERN WITH SUPPLY COORDINATION

As implied by the above discussion, the issue of whether firms in particular industries would gain by the competitive use of signaling investments and the issue of the form of investment that would be used are empirical questions. There are, however, several factors which should contribute to *a priori* prediction of whether such an investment will be made and to determination of the actual form of the investment. In general, the greater the expected loss in the event of supply coordination failure, the greater should be the degree of concern about competitors' investments and the greater should be the value of strategic investment for supply coordination. There are numerous factors which can be expected to bear on the value of strategic investment and hence on the degree of concern with competitors' investments. For convenience they may be grouped under the three general headings of industry growth, industry structure and production technology. Empirical implications derived from each are discussed briefly below.

Industry Growth. As noted earlier, there is nothing to be gained from strategic investment in industries that are not growing. However, it should also be apparent that the cost of coordination failure will tend to be higher for industries that are growing relatively slowly as compared to those growing

rapidly. If growth is slow a coordination failure resulting in excess capacity could depress industry profitability for several years instead of several months, as might be the case if growth were more rapid. By simple extension, the abnormal profits resulting from insufficient capacity should be relatively short lived. Thus, given a sample of growing industries the rate of output growth should be negatively related to the cost of coordination failure and to concern with competitors' investments.

The probability of coordination failure is reduced if firms can adopt simple investment rules such as maintenance of a stable market share. Such rules are more plausible if the rate of industry growth is stable. Hence, concern should decline as the stability of the growth rate rises. By extension, if the pattern of industry growth is unpredictable such rules will be difficult to implement. Industry characteristics contributing to instability of the pattern of growth would include such factors as the prevalance of product and process innovations. It is, therefore, expected that concern with competitors' actions will be higher the more the pattern of actual growth depends on successful product or process innovations.

The rate of facility replacement should be negatively related to concern with coordination failure. This follows from the investment accelerator principle: the more rapid the flow of capital investment the faster the stock of capital can be adjusted toward the optimal level. Excess capacity resulting from coordination failure will be short lived if the capital replacement rate is high. In such cases the expected cost of coordination failure should be low.

Industry Structure. Various aspects of industry structure should also influence the expected cost of coordinator failure. There is an aspect of multiplant economies of scale which is related to the likelihood and cost of coordination failure. By operating multiple plants a firm may gain additional flexibility in adjusting production to deal with excess industry capacity. It may also be better able to adjust its own capacity in small and regular increments rather than quantum jumps, for example, by retiring old facilities at the same time new ones are brought on line. The expected cost of coordination failure should, therefore, fall as the number of plants per firm rises.

Further gains arise from industry concentration. Clearly, as the number of firms in the industry declines the potential number of simultaneous investors also falls. In addition, the cost of learning about competitors' investments is less since there are fewer competitors to keep track of. Thus concentration should reduce the expected cost of coordination failure.

Product differentiation serves as a means of reducing interdependence among firms. As such each firm becomes relatively more concerned with the demand for its own product than with aggregate industry demand. The firm is then more able to expand capacity to meet the demand for its own product without concern for the actions of others in the industry.

Production Technology. It is expected that large size of trade area should evidence low transportation cost relative to product price and will reflect

difficulty of learning about the actions of geographically dispersed competitors. Also, the lower the transportation cost, other things equal, the greater the number of competitors for the same market.

Minimum efficient plant size represents the degree of lumpiness in capacity expansion and suggests costly *ex post* adjustment. If the number of efficient plants in a trade area is small, the potential cost of *ex post* adjustment will tend to increase as will the probable magnitude of coordination failures. In effect, the smaller the trade area the lumpier is an increment to capacity of a given absolute size.

Continuity of the production process is another indication of lumpiness and inflexibility of expansion decisions. Contrast the difficulty of increasing the capacity of an existing oil refinery to that of expanding a pharmaceuticals plant. Longer construction lead times reflect higher cost and greater difficulty of *ex post* adjustment following an over- or under-expansion of capacity.

Empirical Evidence. Empirical analysis in this section focuses on whether the empirical implications of the supply coordination hypothesis as set out above are consistent with actual industry concerns. In the absence of publicly available data that could be used to examine this issue survey methodology was employed. In the fall of 1979 a survey was conducted of corporate planning directors in 45 four digit SIC industries in the United States. There were 167 responses to the survey. Only three of the respondents reported that their industries had not grown or had contracted over the ten year period beginning in 1970. These responses were inconsistent with other responses from the same three industries, all of which indicated that the industries were growing over the period.

Information collected in the survey included descriptive data on the industry as well as information related to concern with expansion and innovation activities of competitors. The latter responses were used to construct an index of concern which is expected to reflect the magnitude of the supply coordination problem. The index was constructed by summing the numerical responses to twelve individual concern factors from the survey.

With respect to each individual factor the survey respondent was presented with a statement such as the following:

> Competitors' expansion plans are very important for major capacity expansion plans of firms in this industry.

The respondent was instructed to indicate the extent of his agreement on a five point scale anchored between "Strongly Agree" and "Strongly Disagree." In an effort to avoid systematic response bias the purpose of the survey was described only in very general terms pertaining to the investment decisions of firms; and the twelve factors indicating concern with interdependence of firms in the industry were interspersed with fourteen other factors pertaining to more general considerations such as availability of labor, capital, raw materials, etc. The list of factors used to construct the index of concern is provided in

Appendix A, where the relationship of each to the above mentioned independent variables is examined, and the data are described in more detail.

Survey data were augmented with data from the Census of Manufacturing in order to study the determinants of the degree of concern with competitors' actions.

Results of the OLS regression of the index of concern on industry descriptive data are reported in Table I. The index of concern was employed as a device for enhancing the systematic components of subjective survey responses. Because of the noncardinal scaling of many of the variables, including the dependent variable, coefficients are reported in the table as standardized beta coefficients. A positive sign reflects a positive relationship between the independent variable and the level of concern with supply coordination failure or the intensity of the coordination problem. All of the signs in Table I were correctly predicted based on the supply coordination hypothesis.

TABLE I
INTERDEPENDENCE IN CAPACITY EXPANSION DECISIONS: OVERALL CONCERN

	Standardized Coefficient	*Absolute t-value*
Industry Growth Variables		
Growth rate of quantity output	−.101	.71
Stability of output growth	−.380**	2.42
Growth due to product innovation	.391**	3.67
Growth due to production process innovation	.266**	2.82
Rate of facility replacement	−.099	1.00
Industry Structure Variables		
Number of plants per firm	−.275**	2.05
Industry concentration	−.218**	1.81
Degree of product differentiation	−.109	1.02
Production Technology Variables		
Size of trade area	.089	.86
Minimum efficient plant size	.188	1.12
Number of efficient plants per trade area	−.087	.90
Continuity of the production process	.144*	1.56
Construction lead time for new plant	.147*	1.36
Adjusted R^2	.22	

** = Significant at .05 level in one tail test
* = Significant at .10 level in one tail test

From these results it is possible to conclude that the degree of concern with investment activities of competitors is consistent with the supply coordination hypothesis. That is, concern, as measured by the reported importance of various factors bearing on the firm's investment decision, is greater where the expected cost of coordination failure is greater. That this actually results in

increased investment in signals intended to reduce the likelihood and cost of coordination failure remains to be established, and is dealt with in the next section of the paper.

V. EVIDENCE OF STRATEGIC INVESTMENT

Previous analysis has established that a firm will tend to employ the form of signal investment that can be produced at least cost, other things equal. In this section six alternative means of supply coordination are described briefly: futures markets, long term contracting, product differentiation, innovation, direct capacity investment and government. The purpose of this discussion is to establish the feasibility of the various alternatives as mechanisms for coordinating expansion.

Having identified the alternative means by which supply coordination may occur, the empirical analysis in this section will examine the relationship between concern with coordination failures of different types and the form of strategic investment employed.

Futures Markets. If there is an active futures market for a product then capacity plans may be coordinated without strategic investment by any supplier. The price of the futures contract will quickly reflect any change in planned supply even in the absence of deliberate action on the part of individual suppliers. However, the ability of such markets to solve the coordination problem is entirely incidental. Futures markets arise from the private demand for price and quantity insurance on the parts of both producers and users. The inability of sellers to diversify by other means, homogeneity of products, and the existence of very large purchasers relative to producers make such markets feasible. Some agricultural markets function this way. The relative inability of individual farmers to diversify against crop specific and location specific risks by other means, the inability of farmers to profit by product quality depreciation relative to their competitors and the existence of very large purchasers of agricultural products whose individual demands far exceed the output of many individual producers make agricultural futures markets feasible. In such markets, changes in planned acreage are quickly reflected in futures prices which guide later investments. Most markets, however, do not satisfy the restrictive list of necessary conditions. Thus, the use of futures contracts can be expected to be quite limited. Most industries will find it preferable to employ one or more of the other alternatives.

Long Term Contracting. The use of private long term contracts to coordinate capacity expansion plans is similar to the use of futures markets. The fundamental distinction is that buyer and seller negotiate on future production directly rather than through an organized market. The existence of a long-term contract to supply a growing market secures the right to investment in capacity for the contract holders. The basic requirement is that the direction

of future demand growth must be predictable since buyers will find no advantage in long-term contracts for unmarketable products.

An important distinction between futures markets and long term contracts is that in the former, futures prices direct the investments of producers; whereas in the latter, direct knowledge of existence of the contract is necessary. Such information must generally be supplied by one of the contracting parties. If existence of a long term contract will help deter investment in non-contractual areas of the business or areas where contracts are near renewal then the contracting firm has an incentive to announce rather than conceal the fact that a contract has been secured.

Product Differentiation. If the firm's share of residual demand can be made to depend on its share of current demand by product differentiation, then product differentiation may be used to coordinate capacity expansion. The effect of product differentiation is to separate markets for products of different firms, giving a particular firm a relatively strong claim to a given share of the residual demand. Product differentiation to coordinate supply can work only if it lowers the expected cost of supply coordination failure and, hence, the price of the product, or raises the expected value of the product to consumers and if consumers can perceive product differences. The actual mechanism of supply coordination by product differentiation might be any of a variety, such as relative advertising intensity, share of shelf space or relative number of outlets.

Innovation. Coordination of expansion could be achieved by investment in innovation if the result of such an investment is a dominating product or process and if imitation of the innovation is costly for competitors. In effect, the successful innovator gains the right to expand capacity. Alternatively, if imitation is easy the right to benefit from an innovation may be strengthened by a direct investment in new capacity sufficient to supply all of the expected new demand. Thus, capacity investment may provide a means of privatizing the gains from innovations which are easily copied. Other variations for accomplishing the same result, such as licensing, are also possible. The direct use of innovation to coordinate supply is expected to be higher in industries where product and process innovations are important to growth and difficult for competitors to imitate. If imitation is easy some other alternative such as direct investment in capacity should tend to be used.

As is true of long term contracts, if successful innovation confers the right to expand capacity, then the innovator will have an incentive to announce his investment in innovation or his success. Such announcements will tend to discourage similar investments by competitors and thus help establish the right to expand production capacity. For example, in the market for academic research a scholar may discourage others from working in the same area by circulating his working papers at a preliminary stage prior to actual publication.

Direct Investment in Capacity. The market for new capacity may also be coordinated by direct investment in capacity earlier than is actually needed.

For this to be a feasible alternative it must be possible to invest less than the full value of the project and to couple this with an announcement that the investment has been made. For example, a firm might announce that it has acquired the site for a new plant (indicating that it has already invested in determining the feasibility of such a plant and examined the possibilities for location). Similarly, it might announce that it has entered into site development contracts which cannot be broken without cost. Such announcements would tend to influence the investment decisions of competitors.

Government. Finally, capacity expansion may be coordinated by some form of government process that tends to sequence investments. Specific vehicles would include patent laws, business licensing and developmental assistance loans by government. In banking it is common for the State Banking Commissioner to coordinate investment in new facilities by a formal application procedure. Sites will be acquired, and construction contracts awarded "subject to regulatory approval." If two or more banks should decide to branch in the same general area at the same time, typically only one will be approved. It is expected that direct government involvement will tend to be used when other avenues such as product differentiation, innovation and long-term contracts are relatively infeasible.

With respect to government involvement in the coordination process there are special risks. Such systems are prone to abuse and may provide remedies that reduce the private cost to industry of coordination failure, but do not actually help solve the coordination problem. An example might be some form of price control. On the other hand, the potential exists for substantial gains from use of government. Many countries rely heavily on government to coordinate supply. For example, in Austria the Structural Improvements Act provides tax concession to firms to encourage mergers and cooperation. The Fund for Development and Innovation provides credit guarantees to large businesses for capacity expansion and product and process development. These funds are to be allocated based on potential for growth and in such a way as to reduce duplication of effort.

Empirical Evidence. The supply coordination hypothesis would be best supported by evidence that the frequency and form of strategic investments are related to the intensity of concern with coordination failure of different types and to the relative costs of different forms of signals. However, the empirical connection between concern with coordination failure and strategic investment cannot be examined directly since there is no objective criterion that can be used to determine whether the investment, *per se*, is made for strategic reasons.

Even though strategic investment can not be identified as such, the effectiveness of three of the six alternatives for supply coordination discussed above depends on competitors being made aware of the fact that the investment has been made. If investments in capacity or innovation are made, or if long term contracts are entered into, for non-strategic reasons, then there

is no reason to expect a relationship between factors reflecting concern with supply coordination and announcements of such investments. If the investment is strategic the firm will benefit from communicating news of the investment. Thus, it is expected that concern with supply coordination will be related to the contents of trade and financial journal articles pertaining to these events.

For each of the 45 industries surveyed, the number of trade and financial journal articles pertaining to four of the six means of supply coordination were tabulated over a four-year period. The four included: capacity expansion, innovation, government regulation and long-term contracts. The data source was the *Funk and Scott Index of Corporations and Industries.*

Articles relating to futures markets were not collected since, as noted, supply coordination is incidental to the use of such markets and producers have no significant incentive to announce investments directly. Furthermore, the use of futures markets is not prevalent among manufacturing industries. Product differentiation is another means of supply coordination which requires no announcement, hence articles pertaining to product differentiation were not tabulated. Since efforts to coordinate supply by government regulation frequently involve publication of government actions, articles pertaining to government regulations were included.

To control for differences in the total number of articles across industries the number of articles of each type was expressed as a percent of the total and transformed to a logit specification. The result was that four interrelated dependent variables were generated, one for each category of articles.

Since the variables are interrelated expected results can only be discussed in relative terms. It was expected that the percent of articles of a given type would be influenced partly by the degree of activity of that type within the industry, and partly by the degree of concern with supply coordination failure of that type. For example, an industry that is growing rapidly can be expected to produce a relatively large number of articles on new investment in capacity simply because it is growing. But the concern with supply coordination failure in the provision of new capacity depends on the likelihood and expected cost of coordination failure as well. Thus, in industries where concern with competitors' expansion plans is high, it is expected that the use of strategic investments in capacity and the related announcements will also be high.

Similarly the number of articles on innovation will depend on both the rate of innovation and the concern with coordination failure in innovation. Thus, the strategic investment in innovation and the number of articles announcing such investments should increase as the concern with coordination failure of this type rises.

Since the dependent variables are interrelated, anything which appears as an argument explaining one of them is also appropriately included in explaining all the others. This is unavoidable but unfortunate since it results in very lengthy models including a number of collinear independent variables and low significance levels.

Each dependent variable was regressed on the list of variables in Table I along with the set of twelve survey generated variables reflecting various aspects of concern with competitors. The Table I variables serve to control for factors that would tend to produce differences in numbers (and percentages) of articles of different types for nonstrategic reasons, such as differences in rates of growth or innovation.

Results of the analysis are presented in Table II. As can be seen, the individual results are extremely weak. This is not surprising given previous discussion. The significance levels on concern variables are further reduced by the previously acknowledged fact that, as is true of any survey generated variable, they include a high degree of random response error. Also, the dependent variables themselves are subjective.

Recognizing these problems, it is still true that the overall results support the hypothesis that trade and financial journals are being used to communicate information which would tend to ameliorate the supply coordination problem to a degree beyond which can be attributed to industry descriptive factors alone. This conclusion is most easily seen by focusing on the role of a single independent variable in each of the four equations.

The first two variables in the table reflect direct concern with competitor capacity investment. The percent of articles about capacity investment was

TABLE II
PERCENT OF ARTICLES BY TYPE OF ARTICLE
LOG $\left(\frac{p}{1-p}\right)$

	Standardized Coefficients for Each Model (t-values in parentheses) *Article Type*			
Factors Reflecting Concern With Competitors	(1) *Capacity Expansion*	(2) *Innovation*	(3) *Government Regulation*	(4) *Long term Contracts*
1. Competitors' expansion plans	.114	−.080	−.050	−.124
	(.080)	(.79)	(.34)	(.95)
2. Revise plans if another	.052	−.013	−.170	.197
firm builds	(.29)	(.10)	(.58)	(1.31)
3. Patentability of new product	−.096	.125	−.004	−.239
or process	(.75)	(1.42)	(.03)	(2.09)
4. Technological innovation in	−.003	.139	−.095	.003
the production process	(.01)	(1.39)	(.65)	(.03)
5. Plans will be revised if a	−.048	.110	−.138	.144
competitor innovates	(.29)	(.98)	(.83)	(.99)
6. Innovative products will be	.047	.103	−.117	.020
produced only in own plants	(.32)	(1.00)	(.77)	(.15)
7. Government regulation of price	−.044	.141	.211	.249
	(.19)	(.86)	(.87)	(1.18)
8. Government regulation of	.066	−.167	−.395	−.253
output	(.28)	(1.03)	(1.66)	(1.21)
9. Government actions affecting	−.006	−.164	−.060	.139
competitor expansion decisions	(.04)	(1.46)	(.36)	(.95)

10.	New long term sales contracts	.052	−.147	.164	−.117
		(.36)	(1.46)	(1.12)	(.90)
11.	Need to maintain market share	.147	−.023	−.022	−.030
		(1.08)	(.29)	(.15)	(.25)
12.	Feasibility study includes expans. plans of competitors	−.284	.250	.207	−.130
		(1.77)	(2.28)	(1.26)	(.92)
	Industry Descriptive Variables				
13.	Size of trade area	−.179	.185	−.087	.0
		(1.38)	(2.05)	(.65)	
14.	Minimum efficient plant size	.519	−.738	−.221	.070
		(1.95)	(3.98)	(.81)	(.29)
15.	Number of efficient plants per trade area	−.105	.111	.030	−.141
		(.75)	(1.20)	(.22)	(1.18)
16.	Number of plants per firm	−.582	.574	.282	.125
		(2.72)	(3.86)	(1.29)	(.65)
17.	Industry concentration	−.208	.482	.058	−.040
		(1.21)	(4.15)	(.33)	(.27)
18.	Growth rate of output	.354	−.151	−.472	−.220
		(1.72)	(1.08)	(2.24)	(1.22)
19.	Stability of output growth	−.110	−.045	−.396	−.401
		(.42)	(.25)	(1.47)	(1.73)
20.	Growth due to product innovation	.134	.075	−.170	−.101
		(.83)	(.66)	(1.02)	(.69)
21.	Growth due to production process innovation	−.157	.0	−.032	.027
		(1.28)		(.26)	(.23)
22.	Rate of facility replacement	.111	−.167	.068	−.114
		(.87)	(1.87)	(.52)	(.99)
23.	Product differentiation	.105	−.129	−.176	−.069
		(.70)	(1.26)	(1.14)	(.32)
24.	Continuity process of production	−.159	.331	−.153	−.302
		(1.26)	(3.79)	(1.19)	(2.68)
25.	Lead time for new plant construction	.085	.241	−.198	−.134
		(.37)	(2.34)	(1.30)	(1.01)
	Adjusted R^2	.22	.62	.12	.36

expected to be relatively high if concern was high, and low otherwise. Aside from the positive sign on the second variable in model 4, results are consistent with expectations.

The next four variables (3 through 6) relate to concern with product and process innovation. It was expected that these would be positively related to the percent of articles on innovation. In model 2 all four variables are correctly signed. It should also be noted that the relations between variables reflecting concern with innovation and percent of articles on government regulation are always negative. Also there is a strong negative relationship between patentability and per cent of articles on long term contracts. This is consistent with innovation and contracting being substitute mechanisms for supply coordination.

The next three variables (7 through 9) relate to government regulation. These results are confusing, partly because there are many other reasons for

articles about government regulation than just supply coordination and possibly because some responses to the survey pertained to government as an impediment to independent business decisions, rather than as a mechanism for coordination. The strongest set of relationships is between government regulation and innovation, where all signs are negative suggesting that government regulation will not be used to coordinate supply when the potential for accomplishing the same thing by innovation is high.

The negative relationship between variable 10, new long term sales contracts, and innovation was to be expected, as were the positive relationships to direct capacity expansion and government regulation. But the negative relation to percent of articles on long term contracts is inexplicable.

A priori hypotheses about variables 11 and 12 were not attempted since the exact relationship to the dependent variables was not apparent. Interpretation of the remainder of Table II is straightforward. Because of space limitations that interpretation is left to the reader.

Clearly there are other motivations for trade journal announcements. A potentially better test would be to examine the articles for specific evidence of irreversible investment or insurmountable lead. Most did display such evidence, but the degree of judgment required to achieve such a refinement was regarded as too subjective. Stronger results could also be achieved by increasing both the number of firms and industries in the survey. This was not attempted because of financial limitations on the study.

VI. CONCLUDING REMARKS

Strategic behavior on the part of industry participants is generally regarded as leading to some non-optimal outcome such as might be suggested by game theoretic models of duoply, dynamic limit pricing or, most recently, entry deterrence. This analysis has demonstrated that strategic investments may be made by firms which correctly expect to earn no abnormal returns. Furthermore, the result of such strategic behavior may actually be more efficient allocation of resources to production. Empirical evidence has been presented which suggests, first, that supply coordination failure is a true concern of industry and, second, that the pattern of strategic investment, as evidenced by published announcements, is consistent with the pattern and degree of concern about coordination failure. With respect to the policy implications of the supply coordination hypothesis some additional points should be made.

First, for rivalrously competitive industries strategic investments will only be made when they tend to lower the present-valued cost of expansion relative to the nonstrategic alternative of short run profit maximization. This requirement is enforced by potential competition. The role of potential competition and the mechanism by which it works are critical distinctions between the strategic entry deterrence result and the competitive supply

coordination result presented here. If prospective investors are perceived as simply offering their products for sale at some price it would appear that the entry deterrence result is more or less correct. Potential competitors would not be effective in such a case since all that entry would do is cause both existing and new suppliers to incur losses. For potential competition to be effective the possibility for contracting (implicitly or explicitly) with buyers (or their agents) in advance of actual investment must exist. The existence of such contracting arrangements means that the cost of *over*-investment, or *excessive* early investment can be imposed on the firm making the strategic investment. In other words outsiders could "hold up" insiders for the present value of excess investment. This would be sufficient to produce the rivalrously competitive price and output.

Second, there is no *a priori* reason to expect insiders to do the preempting of outsiders. A new entrant would choose to act in exactly the same way. That is, what we are observing is strategic behavior but not deliberate deterrence of new entry. However, it is easy to see why insiders might find new investment to be profitable sooner than prospective entrants and would therefore make strategic investments earlier. The reasons why this might be true include such factors as the multiplant economies discussed earlier. The result could be increasing concentration, but not in a manner that is inconsistent with economic efficiency. This is related to Williamson's [13] notion of the first mover advantage.

Finally, it is worth noting that change in government policy or regulations may affect the relative advantages of the mechanisms used for supply coordination. For example, restrictions on advertising or on creation of brand names may cause an increase in the rate of direct investment in capacity.

ARIZONA STATE UNIVERSITY, TEMPE ACCEPTED APRIL 1981

APPENDIX A

Independent variables used in the analysis are as follows:

1. *Size of trade area* was generated by survey responses to the statement: "Most of the production of a 'typical' plant in this industry is used within [100, 500, 1500, over 1500] miles of the plant."
2. *Minimum efficient plant size* was midpoint plant size in terms of employees based on the 1972 Census of Manufacturing.
3. *Number of efficient plants per trade area* was elicited from survey responses to the question: ". . . how many ["typical" new plants] do you believe would be needed to serve the market area of [a] plant" (as described above)?
4. *Number of plants per firm* was the ratio of establishments to firms as reported in the Census of Manufacturing.

5. *Industry concentration* was the four firm concentration ratio for value added as reported in the Census.
6. *Growth rate of quantity output* was the annual percentage growth rate in real output as determined by deflating value of shipments by approximating the Bureau of Labor Statistics price indexes from 1960 through 1976.
7. *Stability of output growth* was the mean growth rate divided by its standard deviation.
8. *Growth due to product innovation* was based on survey responses to the statement "For the most part growth in this industry is the result of new production innovation."
9. *Growth due to production process innovation* was based on survey responses to a similar statement.
10. *Rate of facility replacement* was based on the survey. Respondents were asked to characterize their industries as undergoing rapid and continual replacement of plants, in transition with new plants being phased in slowly, or characterized by old outmoded plants.
11. *Degree of product differentiation* was based on a survey query asking the respondent to rank his product on a five point scale from undifferentiated to unique.
12. *Continuity of the production process* was based on survey responses characterizing the "typical work flow" as separate specialized shops, interrelated work stations or continuous assembly line.
13. *Construction lead time* was based on survey responses to the question: "What do you believe would be the expected duration of time from when the decision to build. . .a plant or factory was made until the plant or factory was on line and producing?" Permissible responses ranged from 6 months or less to over 5 years.

A more complete analysis of the relationships between industry descriptive characteristics and concern with expansion plans of competitors is presented in Table A-1. The table disaggregates the index of concern used in Table I into twelve components based on original survey responses. Because of the subjective nature of the responses and the high degree of response error it was not expected that the relationships would be strong. Restrictions on length preclude a complete discussion of these results. Interested readers are encouraged to contact the author for further information on the survey, the methodology or interpretation of results.

The results in Table A-1 can be used to help interpret those in Table I. For example, from Table A-1 it is apparent that the negative sign on size of trade area in Table I results primarily from concerns with innovation and long term contracts. The negative sign for number of plants per firm arises mainly from factors reflecting direct concern with capacity and concern with innovation. The negative sign on concentration is not attributable to any specific concerns, rather it is a fairly general result. The negative sign on stability of output

TABLE A-1
INTERDEPENDENCE IN CAPACITY EXPANSION DECISIONS: SPECIFIC CONCERNS

Industry Descriptive Variables	*Standardized Coefficients of Concern Factors*					
	Competitors' Expansion Plans	*Revise plans if another firm builds*	*Patentability of new product or process*	*Tech. innov. in the prod. process*	*Plans will be revised if compet. innov.*	*Innov. prod. will be produced only in own plants*
Size of trade area	−.191	−.021	.101	.163	.023	.011
	(1.57)	(.18)	(.75)	(1.35)	(.19)	(.10)
Minimum efficient plant size	.080	.545**	.086	−.091	.372	−.003
	(.36)	(2.62)	(.34)	(.41)	(1.65)	(.01)
Number of efficient plants per trade area	.118	−.051	.019	−.132	.130	−.052
	(1.00)	(.46)	(.14)	(1.13)	(1.10)	(.46)
Number of plants per firm	−.012	−.629**	−.175	−.160	−.513**	.083
	(.06)	(3.81)	(.88)	(.91)	(2.88)	(.49)
Industry concentration	−.434**	.103	−.029	−.235	−.037	.114
	(2.90)	(.74)	(.18)	(1.58)	(.25)	(.80)
Growth rate of quantity output	.221	−.025	−.204	−.452**	−.211	−.288*
	(1.26)	(.15)	(1.05)	(2.60)	(1.20)	(1.72)
Stability of output growth	−.512**	−.234	−.259	−.747**	−.245	.136
	(2.31)	(1.14)	(1.05)	(3.40)	(1.11)	(.65)
Growth due to product innovation	−.011	−.139	.528**	.468**	.203**	.270**
	(.09)	(1.23)	(2.42)	(3.86)	(1.66)	(2.32)
Growth due to production process innovation	.039	.231**	.013	.029	.211*	.092
	(.35)	(2.25)	(.10)	(.26)	(1.90)	(.87)
Rate of facility replacement	−.168	−.048	−.110	−.126	−.089	−.020
	(1.37)	(.42)	(.81)	(1.04)	(.73)	(.18)
Degree of product differentiation	.058	.121	.110	.224*	.046	.127
	(.44)	(.98)	(.75)	(1.70)	(.34)	(1.00)
Continuity of the production process	.049	.335**	.020	.172	.158	.058
	(.43)	(3.19)	(.15)	(1.53)	(1.39)	(.53)
Construction lead time for new plant	.005	−.129	.202	.117	−.225*	−.129
	(.03)	(1.09)	(1.43)	(.92)	(1.77)	(1.06)
R^2	.33	.43	.18	.35	.33	.40
Adj R^2	.21	.32	.02	.22	.21	.28

Standardised Coefficients of Concern Factors

	Government regulation of price	*Government regulation of output*	*Govt. action Affecting compet. expans. plans*	*New long term sales Contracts*	*Need to maintain mkt. shares*	*Feasibility study incl. expans. plans of compet.*
Size of trade area	−.085	.022	−.069	.173	.100	.014
	(.66)	(.17)	(.58)	(1.49)	(.78)	(.11)
Minimum efficient plant size	.150	−.076	−.351	−.300	.270	−.236
	(.63)	(.32)	(1.60)	(1.39)	(1.07)	(1.01)
Number of efficient plants per trade area	−.115	−.189	−.242**	−.207*	.187	−.094
	(.92)	(1.50)	(2.09)	(1.85)	(1.42)	(.77)
Number of plants per firm	−.054	.115	.095	−.084	−.159	−.134
	(.28)	(.60)	(.55)	(.49)	(.80)	(.72)
Industry concentration	.026	−.021	−.258	−.257*	−.217	−.413*
	(.16)	(.13)	(1.63)	(1.79)	(1.30)	(2.67)
Growth rate of quantity output	.407**	.264	−.049	−.309*	−.190	−.535**
	(2.19)	(1.41)	(.28)	(1.84)	(.97)	(2.94)
Stability of output growth	.295	.001	−.346	−.657**	−.154	−.755**
	(1.26)	(.01)	(1.60)	(3.10)	(.62)	(3.30)
Growth due to product innovation	.067	.065	.353**	.527**	.193	.181
	(.52)	(.50)	(2.79)	(4.50)	(1.41)	(1.43)
Growth due to production process innovation	.198*	.152	.201*	.063	.050	−.012
	(1.68)	(1.28)	(1.86)	(.59)	(.40)	(.10)
Rate of facility replacement	.114	.087	−.105	.115	−.061	−.084
	(.88)	(.67)	(.88)	(.98)	(.44)	(.66)
Degree of product differentiation	−.347**	−.299**	−.330**	−.005	−.026	.182
	(2.46)	(2.11)	(2.54)	(.03)	(.17)	(1.32)
Continuity of the production process	−.099	.026	.006	.067	.361	.300**
	(.83)	(.22)	(.05)	(.62)	(1.27)	(2.56)
Construction lead time for new plant	.312**	.278**	.385**	.226*	−.237	.024
	(2.31)	(2.04)	(3.08)	(1.85)	(1.65)	(.18)
R^2	.25	.24	.36	.39	.17	.29
	.11	.10	.24	.27	.01	.15

** − Significant at .05 level
* − Significant at .10 level

growth is also a general result. Product innovation is positive for all factors except direct concerns about capacity and process innovation is positive for almost all factors. The negative sign on product differentiation reflects mainly concern with government regulation. The positive sign on continuity of the production process is almost universal and the positive sign on construction lead time to also fairly general.

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