A SUPERGAME-THEORETIC MODEL OF BUSINESS CYCLES AND PRICE WARS DURING BOOMS

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This paper studies implicitly colluding oligopolists facing fluctuating demand. The credible threat of future punishments provides the discipline that facilitates collusion. However, we find that the temptation to unilaterally deviate from the collusive outcome is often greater when demand is high. To moderate this temptation, the optimizing oligopoly reduces its profitability at such times, resulting in lower prices. If the oligopolists' output is an input to other sectors, their output may increase too. This explains the co-movements of outputs which characterize business cycles. The behavior of the railroads in the 1880's, the automobile industry in the 1950's and the cyclical behavior of cement prices and price-cost margins support our theory. (J.E.L. Classification numbers: 020, 130, 610).
I. INTRODUCTION

This paper has two objectives. First, it is an exploration of the way in which oligopolies react to changing demand for their products. In particular we argue that oligopolies are likely to behave more competitively when their demand is high. Second, we study the connection between this oligopolistic behavior and business cycles. We show that it is possible that the increase in competitiveness that results from a shift in demand towards goods produced by oligopolies may be sufficient to raise the output of all sectors. This brings about a boom. Finally, we explore the empirical relevance of the model. We show that in practice various oligopolistic industries tend to have relatively low prices when their demand is high. The few price wars which have been documented also seem to have taken place during periods of high demand.

We examine implicitly colluding oligopolies of the type introduced by Friedman (1971). These obtain above competitive profits by the threat of reverting to competitive behavior whenever a single firm does not cooperate. This threat is sufficient to induce cooperation by all firms. It must be pointed out that there are usually a multitude of equilibria in such settings. Following Porter (1983a) we concentrate on the best equilibrium of this type the oligopoly can achieve.

The basic point of this paper is that oligopolies find implicit collusion of this type more difficult when their demand is relatively high. The reason for this is simple. When demand is relatively high and price is the strategic variable the benefit to a single firm from
undercutting the price which maximizes joint profits is larger. A firm which lowers its price slightly gets to capture a larger market until the others are able to change their prices. On the other hand, the punishment from deviating is less affected by the state of demand if punishments are meted out in the future and demand tends to return to its normal level. Thus, when demand is high the benefit from deviating from the output that maximizes joint profits may exceed the punishment a deviating firm can expect.

What should the oligopoly do when it cannot sustain the level of output that maximizes joint profits? It basically has two alternatives. The first is to give up any attempt to collude when demand is high. This leads to competitive outcomes in booms. Such competitive outcomes are basically price wars. The second, more profitable, alternative is to settle for the highest level of profits (lowest level of output) which is sustainable. As the oligopoly attempts to sustain lower profits the benefits to a deviating firm fall. Thus, for a given punishment, there is always a level of profits low enough that no single firm finds it profitable to deviate. As demand increases, the oligopoly generally finds that the incentive to deviate is such that it must content itself with outcomes further and further away from those that maximize joint profits.

Our strongest results are for the case in which prices are the strategic variable and marginal costs are constant. Then, increases in demand beyond a certain point actually lower the oligopoly's prices monotonically. This occurs for the following reason: Suppose the oligopoly were to keep its prices constant and only increase output in response to higher demand. Then industry profits would increase when demand goes up. However, in this case, a deviating firm can capture the entire industry profits by shading its price slightly. Therefore constant prices would
increase the incentive to deviate. Reductions in price are needed to maintain implicit collusion.

It might be thought that if firms are capacity constrained in booms they are essentially unable to deviate so that the oligopoly doesn't have to cut prices in booms. Indeed, we find that when marginal costs increase with output, a more plausible way of capturing the importance of capacity, our results are weaker. Nonetheless, even in this case the equilibrium can be more competitive when demand is high whether output or price is the strategic variable.

Next we consider the connection with business cycles. We want to establish that shifts in demand towards oligopolistic sectors can raise the output of all goods. The hallmark of business cycles is that the outputs of different sectors move together. With competitive markets and perfect information it is difficult to obtain such comovements in response to changes in demand. Yet, it is precisely changes in demand that traditional Keynesian models have emphasized as causing business cycles.

We consider an extremely simple two sector general equilibrium model which is capable of generating these comovements in response to changes in demand. One of the sectors is oligopolistic while the other is competitive. The oligopolistic sector's output can be used either as an intermediate input in the competitive sector or for consumption. When consumers shift their demand towards the oligopolistic sector, this sector lowers its prices. This, in turn leads the competitive sector to increase its purchases from the oligopolistic sector and thus increase its output as well. So, both sectors grow, only to shrink when demand moves back towards the competitive sector.
Any theory whose implication is that competitive behavior is more likely to occur in booms must confront the industrial organization folklore which is that price wars occur in recessions. This folklore is articulated for example in Scherer (1980). Our basis for rejecting this folklore is not theoretical. We concede that it is possible to construct models in which recession induce price wars.\(^1\),\(^2\) Indeed, in a model with imperfect observability of demand, Green and Porter (1984) show that price wars occur when demand is unexpectedly low. Then, firms switch to competition because they confuse the low price that prevails in equilibrium with cheating on the part of other firms.

Instead, our rejection of the folklore is based on facts. First, at a very general level, it certainly appears that business cycles are related to sluggish adjustment of prices (see Rotemberg (1982) for example). Prices rise too little in booms and fall too little in recessions. If recessions tended to produce massive price wars this would be an unlikely finding. More specifically we analyze some other data capable of shedding light on the folklore.

What we find is that both Scherer's evidence and our own study of the cyclical properties of price cost margins support our theory. The ratio of prices to our measure of marginal cost tends to be countercyclical in more concentrated industries. Our theory is also supported by an analysis of the price wars purported to have happened in the automobile industry (Bresnahan (1981)) and the railroad industry (Porter (1985a)). These wars have occurred in periods of high demand. Finally, since Scherer singles out the cement industry as having repeated break-ups of its cartel during recessions, we study the cyclical properties of cement prices. To our
surprise, cement prices are strongly countercyclical even though cement, as construction as a whole, has a procyclical level of output.

The paper proceeds as follows. Section II presents our theory of oligopoly under fluctuating demand. Section III considers the general equilibrium model which forms the basis of our discussion of macroeconomics. Section IV contains the empirical regularities which lend some plausibility to our theory. We conclude with Section V.

II. EQUILIBRIUM IN OLIGOPOLISTIC SUPERGAMES WITH DEMAND FLUCTUATIONS

We consider $N$ symmetric firms producing a homogeneous good in an infinite-horizon setting. It is well-known that infinitely lived oligopolies of this type are usually able to sustain outcomes in any period that strictly dominate the outcome in the corresponding one-period game even if firms cannot sign binding contracts. In order to achieve this the equilibrium strategies must involve a mechanism that deters an individual firm from "cheating" (by expanding output or by shading prices). One such mechanism and one that has been fruitfully employed in theoretical models$^3$, is the use of punishments against the defecting firm in periods following the defection. If these punishments are large enough to outweigh the gain from cheating the collusive outcome is sustainable.

In order for the equilibrium strategies to be sequentially rational$^4$, however, it must be the case that if a defection actually occurs the non-defecting firms are willing to mete out the proposed punishment. A simple and often employed way (see Green and Porter (1984) for example) to ensure sequential rationality is for punishments to involve playing the equilibrium strategies from the one-period game for some fixed period of time. We also restrict attention
to strategies of this kind. In addition to their simplicity and conformity with the literature they are also optimal punishments in some cases.\textsuperscript{5} The major departure of our model from those that have previously been studied is that we allow for observable shifts in industry demand. We denote the inverse demand function by $P(Q_t, \tilde{e})$ where $Q_t$ is the industry output in period $t$ and $\tilde{e}$ is the random variable denoting the observable demand shock (with realization $e_t$ in period $t$). We assume that increases in $e_t$ result in higher prices for any $Q_t$, that $\tilde{e}$ has domain $[\underline{e}, \bar{e}]$ and a distribution function $F(e)$ and that these are the same across periods (i.e. shocks are i.i.d.). We denote firm $i$'s output in period $t$ by $q_{it}$ so that

$$Q_t = \sum_{i=1}^{N} q_{it}.$$ 

The timing of events is as follows: At the beginning of the period all firms learn the realization of $\tilde{e}$ (more precisely $e_t$ becomes common knowledge). Firms then simultaneously choose the level of their choice variable (price or quantity). These choices then determine the outcome for that period in a way that depends on the choice variable: in the case of quantities the price clears the market given $Q_t$; in the case of prices the firm with the lowest price sells as much as it wants at its quoted price; the firm with the second lowest price then supplies as much of the remaining demand at its quoted price as it wants, and so on. The strategic choices of all the firms then become common knowledge and this one-period game is repeated.

The effect of the observability of $e_t$ and the key to the difference between the model and its predecessors is the following: The punishments that firms face depend on the future realizations of $\tilde{e}$. The expected value of such punishments therefore depends on the expected value of $\tilde{e}$. However the reward
for cheating any period depends on the observable $\epsilon_t$. We show that for a wide variety of interesting cases the reward for cheating from the joint profit-maximizing level is monotonically increasing in $\epsilon_t$. If $\epsilon_t$ is large enough, the temptation to cheat outweighs the punishment. The observability of $\epsilon_t$ allows the oligopoly to recognize this fact. Thus an implicitly colluding oligopoly may settle on a profit below the fully collusive level in periods of high demand to adequately reduce the temptation to cheat. Such moderation of its behavior tends to lower prices below what they would otherwise be, and may indeed cause them to be lower than for states with lower demand. We illustrate this phenomenon for both the case in which prices and the case in which quantities are the strategic variables.

(a) Price as the strategic variable

We begin with an analysis of the case in which marginal costs (and average costs) are equal to a constant $c$. This is an appropriate assumption if capacity is very flexible in the short run, if firms produce at under capacity in all states or if firms produce to order and can accumulate commitments for future deliveries. There always exists an equilibrium in which all the firms set $P=c$ in all periods. Firms then expect future profits to be zero whether they cooperate at time $t$ or not. Accordingly the game at time $t$ is essentially a one-shot game in which the unique equilibrium has all firms setting $P=c$. In what follows we concentrate instead on the equilibria that are optimal for the firms in the industry.

We begin by examining the oligopoly's options for each value of $\epsilon_t$. Figure 1 shows the profits of each firm, $\Pi$, as a function of the aggregate output, $Q$, for a variety of values of $\epsilon_t$. These profit loci are drawn assuming each firm supplies $1/N$ of $Q$. As $\epsilon_t$ increases, the price for each
FIGURE 1

PROFITS OF THE OLIGOPOLY
\( Q_t \) rises so that profits are increasing in \( \varepsilon_t \). \( \Pi^m(\varepsilon_t) \) denotes the profit of an individual firm in state \( \varepsilon_t \) if the firms each produce \( q^m \) which equals \( 1/N \) of the joint profit-maximizing output, \( q_t^m \). Notice that \( \Pi^m(\varepsilon_t) \) is increasing in \( \varepsilon_t \) since profits are increasing in \( \varepsilon_t \) even holding \( Q_t \) constant.

If a firm deviates from this proposed outcome it can earn approximately \( \Pi^m \) by cutting its price by an arbitrarily small amount and supplying the entire market demand. Firm \( i \) would therefore deviate from joint profit-maximizing output if

\[
\Pi^m(\varepsilon_t) - K > \Pi^m(\varepsilon_t) \quad \text{i.e. if} \quad \Pi^m(\varepsilon_t) > K/(N-1),
\]

where \( K \) is the punishment inflicted on a firm in the future if it deviates at time \( t \). It is thus the difference between the expected discounted value of profits from \( t+1 \) on if the firm goes along and the expected discounted value of profits if it deviates.

For the moment we will take \( K \) to be exogenous and independent of the value of \( \varepsilon_t \) at the point that cheating occurs. (We will prove the latter shortly and also endogenize \( K \)).

Since \( \Pi^m(\varepsilon_t) \) is increasing in \( \varepsilon_t \), there is some highest level of demand shock, \( \varepsilon_t^* (K) \), for which \((N-1) \Pi^m(\varepsilon_t^*) = K \). We consider separately the cases in which \( \varepsilon_t \) is below and above \( \varepsilon_t^* \). In the former cases no individual firm has an incentive to deviate from the joint profit-maximizing outcome.

Therefore, if we define \( \Pi^S(\varepsilon_t, \varepsilon_t^*) \) to be the highest profits the oligopoly can obtain, \( \Pi^S(\varepsilon_t, \varepsilon_t^*) = \Pi^m(\varepsilon_t^*) \). In the latter case, however, the monopoly profits are not sustainable since any individual firm would have an incentive to cheat. In this case the maximum sustainable profits are given by

\[
(N-1)\Pi^S(\varepsilon_t, \varepsilon_t^*) = K.
\]
In summary,

\[ \Pi^{S}(c_t^*, c_t^*) = \begin{cases} 
\Pi^{M}(c_t) & \text{for } c_t < c_t^* \\
\frac{K}{\delta^{t-1}} & \text{for } c_t > c_t^*. 
\end{cases} \tag{2} \]

From (2) it is clear that the sustainable profits are higher the higher is the punishment. Since we want to concern ourselves with equilibrium strategies that are optimal for the oligopoly we concentrate on profits that are as large as possible. These involve the lowest possible present discounted value of profits if the firm deviates. Thus charging a price equal to \( c \) in all periods following a defection seems optimal, particularly since such punishments never need to be implemented in equilibrium.\(^7\)

However, there are several related reasons why such infinite-length punishments are unlikely to be carried out in practice. First, once the punishment period has begun the oligopoly would prefer to return to a more collusive arrangement. Second, if the industry members (whether they be firms or even management teams) change over time, shorter punishments seem more compelling. Finally, one can think of the reason why firms succeed in punishing each other at all (even though punishments are costly) is because of the anger generated when a rival cheats on the implicit agreement. This anger, as any "irrational" emotion, may be short lived.

The presence of relatively short punishments, (which in our model are equivalent to low values for \( \delta \), the rate at which firms discount the future) is important to our analysis because such relatively low \( \delta \)'s make \( K \) low. Otherwise the inequality in (1) is always satisfied i.e. in all states of
nature the punishment exceeds the benefits from cheating from the collusive price. This is particularly true if the length of the period in which a firm can undercut its competitor's price successfully is short. Thus the inequality in (1) is also more likely to be violated for high $\varepsilon_t$ if firms are fairly committed to their current prices as they would be if adjusting prices were costly.

For simplicity in what follows we assume an infinite punishment period and hence $\delta$ should be interpreted as being quite small. Then, with price equal to marginal cost, the punishment is equal to the discounted present value of profits that the firm would have earned had it not deviated, or

$$K = \frac{\delta}{1-\delta} \int_0^\infty \Pi (\varepsilon, c^*_t) \, dF(\varepsilon).$$

Even if we allow $K$ to depend on $\varepsilon_t$, the right hand side of (2) is independent of $\varepsilon_t$. Therefore the punishment is indeed independent of the state. Using (2) we can rewrite (3) as:

$$K(c^*_t) = \frac{\delta}{1-\delta} \left[ \int_0^{c^*_t} \Pi^c(\varepsilon) \, dF(\varepsilon) + (1-F(c^*_t))\Pi^m(c^*_t) \right].$$

This gives a mapping from the space of possible punishments into itself: a given punishment implies a cutoff $c^*_t$ from (2) which in turn implies a new punishment from (4).

The equilibria of the model are the fixed points of this mapping. The equilibrium that is optimal for the oligopoly is the one corresponding to the fixed point with the highest value of $K$. 
It remains to provide sufficient conditions for the existence of a fixed point i.e. to show there exists an \( c^* \in (\bar{c}, \bar{c}) \) for which (2) and (4) hold.

Let \( \epsilon_t^* \) be a candidate for such an \( c^* \) and define

\[
 g(\epsilon_t^*) = \Pi^m(\epsilon_t^*) - K(\epsilon_t^*)(N-1)
\] (5)

We need to show there exists an \( \epsilon_t^* \in (\bar{c}, \bar{c}) \) such that \( g(\epsilon_t^*) = 0 \). Using (4) and (5):

\[
 g(\epsilon) = \Pi^m(\epsilon) \left( 1 - \frac{\delta}{(1-\delta)(N-1)} \right)
\]

which is negative if

\[
 N < 1/(1-\delta).
\] (6)

In other words, for \( N \) small enough relative to the discount factor \( \delta \), it is possible to obtain the monopoly outcome in at least the lowest state of demand. As \( N \) gets bigger, or as firms discount the future more (\( \delta \) smaller), the punishments become less important and (6) fails.

On the other hand:

\[
 g(\epsilon) = \Pi^m(\epsilon) - \frac{\delta}{(N-1)(1-\delta)} \int_{\bar{c}}^{\epsilon} \Pi^m(\epsilon) \, dF(\epsilon)
\]

which is positive if

\[
 \frac{\Pi^m(\epsilon)}{\int_{\epsilon}^{\bar{c}} \Pi^m(\epsilon) \, dF(\epsilon)} > \delta/(1-\delta)(N-1)
\] (7)

This condition ensures that the monopoly outcome is not the only solution in every state. This follows when there is sufficient dispersion in the distribution of profit maximizing outputs. If there is no dispersion, (7) ensures that there is never any incentive to cheat. The LHS of (7) is a measure of dispersion of profits.

If conditions (6) and (7) are satisfied we have: (a) \( g(\epsilon_t^*) \) is continuous, (b) \( g(\bar{c}) > 0 \), and (c) \( g(\epsilon) < 0 \), which imply the existence of an
\( e'_t \in (\xi'_t, \xi'_t) \) such that \( g(e'_t) = 0 \) as required.

This equilibrium has several interesting features. In particular, for \( e'_t > e^*_t \) it can be shown that the higher is demand (the higher is \( e'_t \)), the higher is equilibrium output and the lower is the equilibrium price. When \( e'_t \) exceeds \( e^*_t \), \( \Pi^g = Q'_t(P'_t - c) \) is constant. Also, \( Q'_t \) must be as high as possible without reducing firm profits below the sustainable level. In other words, firms must be at \( Q^b_t \) in figure 1 and not at \( Q^g_t \). Otherwise a deviating firm can earn more than \( NT^g \) by cutting its price.

Since output is above \( Q^m_t \), profits fall as \( Q_t \) rises as can be seen in figure 1. On the other hand, for a constant \( Q_t \), \( Q'_t(P'_t - c) \) rises as \( e'_t \) rises since \( P'_t \) is larger. Therefore an increase in \( e'_t \) must be accompanied by an increase in \( Q'_t \). Since increases in \( e'_t \) raise profits, increases in \( Q'_t \), which lower profits, are required to restore the original level of profits.
Moreover, if \( Q'_t(P'_t - c) \) is constant while \( Q_t \) rises, \( P_t \) must fall. So the oligopoly must actually lower its prices to deter deviations.

The model has some intuitive comparative statics. When \( N \) increases and when \( \delta \) decreases, \( e^*_t \) falls. In both cases, cheating becomes more tempting, either because the punishments are distributed among more firms or because they are discounted more. Thus, the oligopoly must content itself with fewer states in which the monopolistic output is sustained. This can be seen by the following three-part argument.

First, the fact that \( g(\delta') \) is positive ensures that \( g \) is increasing in \( e \) at the largest value of \( e' \) for which \( g(e') = 0 \). Second, for fixed \( Q_t \) and \( e_t \) the profits of a single firm are one \( N^{th} \) of the total profits of the industry. Thus, for a fixed \( e^*_t \), equation (4) implies that \( K \) and \( H^m(e^*_t) \) are inversely proportional to \( N \). Therefore, increases in \( N \) raise \( g \) since they
raise \( n^m (c^*_t) \) relative to \( k/(k-1) \) i.e. the temptation to cheat increases. Similarly, a decrease in \( \delta \) raises \( c \) since \( k \) falls. Finally, the increases in \( g \) brought about either by an increase in \( k \) or a reduction in \( \delta \) implies that \( c^*_t \) must fall to restore equilibrium.

As was mentioned above, punishments are never observed in equilibrium. Thus the oligopoly doesn't fluctuate between periods of cooperation and noncooperation as in the models of Green and Porter (1984). To provide an analogous model, we would have to further restrict the strategy space so that the oligopoly can choose only between the joint monopoly price and the competitive price. Such a restriction is intuitively appealing since the resulting strategies are much simpler and less delicate. With this restriction on strategies the firms know that when demand is high the monopoly outcome cannot be maintained. They therefore assume that the competitive outcome will emerge, which is sufficient to fulfill their prophecy. In many states of the world the oligopoly will earn lower profits than under the optimal scheme we have analyzed. As a result, since punishments are lower, there will be fewer collusive states than before. There will still be some cutoff, \( c^*_t \), that delineates the cooperative and noncooperative regions. In contrast to the optimal model, however, the graph of price as a function of state will exhibit a sharp decline after \( c^*_t \) with \( P = c \) thereafter.

The above models impose no restrictions on the demand function except that it be downward sloping and that demand shocks move it outwards. However the model does assume constant marginal costs. The case of increasing marginal cost is more complex than that of constant marginal costs for four reasons: (1) A firm that cheats by price-cutting does not always want to
supply the industry demand at the price it is charging. Specifically, it
would never supply an output at which its marginal cost exceeded the price.

(2) Cheating now pays off when $\Pi^d(\epsilon^*, P) > \Pi^s(\epsilon^*) + K$ where $\Pi^d$ is the profit to the firm that defects when its opponents charge $P$. However, $\Pi^d$ is no longer equal to $(N-1) \Pi^s$. Therefore, the sustainable profit varies by state.

(3) With increasing marginal cost cheating can occur by raising as well as by lowering prices. If its opponents are unwilling to supply all of demand at their quoted price a defecting firm is able to sell some output at higher prices. (4) The one-shot game with increasing marginal cost does not have an equilibrium in which price is equal to marginal cost. Indeed the only equilibrium is a mixed strategy equilibrium.\(^1\)

A number of results can nonetheless be demonstrated. There are two cases to consider depending on whether the deviating firms meet all of demand or not. First suppose that deviating firms do not meet all of demand.

Instead the output which equates the monopoly price to their marginal cost is less than demand. This occurs when $N$ is large and when marginal costs rise steeply. Then the deviating firms equate $P(\eta^m, \epsilon^*)$ and $c'(\eta^d)$ where $c'$ is the derivative of total costs with respect to output. By the envelope theorem the change in the deviating firm's profit from an increase in $\epsilon^*$ is

$$\frac{c_{\epsilon^*} \delta P(\eta^m, \epsilon^*)}{\delta \epsilon^*}.$$  The change in profits from going along is

$$\frac{c_{\epsilon^*} \delta P(\eta^m, \epsilon^*)}{\delta \epsilon^*}.$$  The latter is smaller, ensuring that deviations become more tempting as $\epsilon^*$ rises. Now suppose that deviating firms do not meet all of demand. For this (more difficult case we consider an example in which demand and marginal costs are linear:11

$$P = a + \epsilon^* - bQ_t$$  \hspace{1cm} (6)

$$c(\eta^d) = c_0 + \frac{\partial^2 c_1}{\partial \eta^d}.$$  \hspace{1cm} (7)
It is straightforward to show that in this example cheating becomes more desirable as $\varepsilon_t$ rises.\textsuperscript{12} So, as before, if the oligopoly is restricted to either collude or compete, high $\varepsilon_t$'s generate price wars. Alternatively the oligopoly can pick prices $P^S$ which just deter potentially deviating firms. These prices equate $\pi^S$, the profits from going along, with $\pi^d - K$ where $K$ is the expected present value of $\pi^S$ minus the profits obtained when all firms revert to noncooperative behavior.

It is thus possible to calculate the $P^S$'s, the sustainable prices, numerically. For a given value of $K$ one first calculates in which states monopoly is not sustainable. For those states the sustainable price must then be calculated. Since both the sustainable profit, $\pi^S$, and the profit to a deviating firm, $\pi^d$, are quadratic in $P^S$, this involves solving a quadratic equation. The relevant root is the one that yields the highest value of $\pi^S$ that is consistent with the deviating firm planning to meet demand or equating price to marginal cost.

The resulting $P^S$'s then enable one to calculate a new value for $K$: the one that corresponds to the calculated $P^S$'s.\textsuperscript{13} One can thus iterate numerically on $K$ starting with a large number. Since larger values of $K$ induce more cooperation the first $K$ which is a solution to the iterative procedure is the best equilibrium the oligopoly can enforce with competitive punishments. Figure 2 graphs these equilibrium prices and compares them to the monopoly prices as a function of states for a specific configuration of parameters. In particular $\varepsilon_t$ is uniformly distributed over $\{0, 1, \ldots, 80\}$.

As before the price rises monotonically to $\varepsilon_t^*$ and then falls. The major difference here is that eventually the price begins to rise again. The explanation for this is straightforward. In a state with a high value of $\varepsilon_t$, a firm that deviates by shading its price slightly is unwilling to supply all
FIGURE 2

PRICE AS A STRATEGIC VARIABLE

Parameters: \(a=60, b=1, c=0, d=1/3, \delta=.7, N=5\)
that is demanded at its lower price. Instead it will supply only to the point where its marginal cost and its price are equal. Now consider such a state and one with slightly more demand. If the oligopoly kept the same price in both states, an individual firm would find that its payoff from deviating is the same in both states (since it would supply to price equals marginal cost in both) but that its profits from going along are higher in the better state. Thus the oligopoly is able to sustain a higher price in the better state.

b) Quantities as strategic variables.

There are two differences between the case in which quantities are used as strategic variables and the case in which prices are. First, when an individual firm considers deviations from the behavior favored by the oligopoly, it assumes that the other firms will keep their quantities constant. The residual demand curve is therefore obtained by shifting the original demand curve to the left by the amount of the rivals' combined output. Second, when firms are punishing each other the outcome in punishment periods is the Cournot equilibrium.

The results we obtain with quantities as strategic variables are somewhat weaker than those we obtained with prices. In particular it is now not true that any increase in demand (even with constant marginal costs) leads to a bigger incentive to deviate from the collusive level of output. However, we present examples in which this is the case. We also show with an example that increases in demand can, as before, lead monotonically to "more competitive" behavior.

To see that increases in demand do not necessarily increase the incentive to deviate, we consider the following counterexample. Suppose that
FIGURE 3
The Incentive to Deviate with Quantities as the Strategic Variable
demand in states \( \varepsilon_t^1 \) and \( \varepsilon_t^2 \) gives rise to the residual demand curves faced by an individual deviating firm in Figure 3. These demand curves are merely horizontal translations by \((N-1)q^m\) of the depicted residual demand curves. The monopoly price, \( p^m \), is the same in both states because there is no demand at prices above \( p^m \). Although these demand curves may seem somewhat contrived, they will suffice to establish a counterexample. They can be rationalized by supposing that there is a substitute good that is perfectly elastically supplied at price \( p^m \).

A deviating firm chooses output to maximize profits given these residual demand curves. Suppose that this maximum is achieved at output \( D \) and price \( F^d \) for state \( \varepsilon_t^2 \). For this to be a worthwhile deviation it must be the case that the revenues from the extra sales due to cheating \((CD)\) are greater than the loss in revenues on the old sales from the decrease in price from \( P(Q^m,*) \) to \( F^d \). But (except for a horizontal translation) the firm faces the same residual demand curve in both states. Thus by selling at \( F^d \), the extra sales due to cheating are the same at \( \varepsilon_t^1 \) \((AB)\) as at \( \varepsilon_t^2 \) \((CD)\). Moreover the loss in revenue on old sales is strictly smaller at \( \varepsilon_t^1 \). Therefore the firm has a strictly greater incentive to deviate in state \( \varepsilon_t^1 \) than in state \( \varepsilon_t^2 \).

The above counterexample exploits the assumed structure of demand only to establish that the collusive price is the same in both states. We have therefore also proved a related proposition: for any demand function, if the oligopoly keeps its price constant when \( \varepsilon_t \) increases (thus supplying all the increased demand), the incentive to cheat is reduced when demand shifts horizontally. This is why the oligopoly is able to increase the price as the state improves, in the examples we provide below.
As in the case of increasing marginal cost and price as the strategic variable, when demand and costs are linear as in (8) and (9), an increase in $c_t$ always leads to a bigger incentive to deviate from the collusive output. Then, as before, if the only options for the oligopoly are to either compete or collude, price wars emerge when demand is sufficiently high. Alternatively, the oligopoly can choose a level of output that will just deter firms from deviating when demand is high. The equilibrium levels of output can be obtained numerically in a manner analogous to the one used to calculate the equilibrium sustainable prices in the previous subsection.

Figure 4 plots the ratio of this equilibrium price to the monopoly price as a function of $c_t$. While the equilibrium price rises as $c_t$ rises, it can be seen that beyond a certain $c_t$ the ratio of equilibrium price to monopoly price falls monotonically.

III. BUSINESS CYCLES

So far we have considered only the behavior of an oligopoly in isolation. For this behavior to lead to business cycles we need to model the rest of the economy. While the principle which underlies these business cycles is probably quite general we illustrate it with a simple example. We consider a "real" two sector general equilibrium model in which the first sector is competitive while the second is oligopolistic. There is also a competitive labor market. To keep the model simple it is assumed that workers have a horizontal supply of labor at a wage equal to $P_{1t}$, the price of the competitive good. Since the model is homogeneous of degree zero in prices, the wage itself can be normalized to equal one. So the price of the good produced competitively must also equal one. This good can be produced
OUTPUT AS A STRATEGIC VARIABLE
Parameters: \( a=60, b=1, c=0, d=1/3, \delta = .7, N=5 \)
with various combinations of labor and good 2. In particular the industry-wide production function of good 1 is given by:

\[
Q_{1t} = \alpha Q_{2t} + \frac{\beta Q_{21t}^2}{\xi} + \gamma L_{1t} + \frac{\xi L_{21t}^2}{\xi}
\]  

(10)

where \(Q_{1t}\) is the output of the competitive sector at \(t\), \(Q_{21t}\) is the amount of good 2 employed in the production of good 1 at \(t\) and \(L_{1t}\) is the amount of labor used in the production of good 1. Since the sector is competitive the price of each factor and its marginal revenue product are equated. Thus:

\[
L_{1t} = \frac{(1 + \gamma)}{\xi}
\]  

(11)

\[
P_{2t} = \alpha - \beta Q_{21t}.
\]  

(12)

On the other hand the demand for good 2 by consumers is given by:

\[
P_{2t} = n - mQ_{2ct} + e_t
\]  

where \(Q_{2ct}\) is the quantity of good 2 purchased by consumers, \(n\) and \(m\) are parameters and \(e_t\) is an i.i.d. random variable. Therefore total demand for good 2 is given by:

\[
P_{2t} = a + \varepsilon_t - bQ_{2t}
\]  

\[a = (\mu \beta + \mu \gamma)/(\mu + \beta)\]

\[\varepsilon_t = e_t \beta/(\mu + \beta)\]

(13)

Note that equation (13) is identical to equation (8). To continue the parallel with our sections on partial equilibrium we assume that the labor requirement to produce \(Q_{2t}\) is:

\[
L_{2t} = cQ_{2t} + (d/2)Q_{2t}^2.
\]

which implies that, as before, marginal cost is \(c + dQ_{2t}\). The model would be unaffected if good 1 were also an input into good 2 since \(P_{1t}\) is always equal to the wage. If sector 2 behaved competitively marginal cost would equal \(P_{2t}\). Then output of good 2 would be \(Q_{2t}^C\) while price would be \(P_{2t}^C\).
\begin{align*}
\zeta_{2t} &= (a + \varepsilon_t - c)/(b/2 + d) \\
\rho_{2t} &= ((a + \varepsilon_t)d + bc/2)/(b/2 + d)
\end{align*}

An increase in \( \varepsilon_t \) raises both the competitive price and the competitive quantity of good 2. By (12) less of good 2 will be used in the production of good 1 thus leading to a fall in the output of good 1. So, a shift in tastes raises the output of one good and lowers that of the other. The economy implicitly has, given people's desire for leisure, a production possibility frontier.

Similarly, if sector 2 always behaves like a monopolist, increases in \( \varepsilon_t \) raise both \( P_{2t} \) and \( Q_{2t} \) thus lowering \( Q_{1t} \). Once again shifts in demand are unable to change the levels of both outputs in the same direction. On the other hand if the industry behaves like the oligopoly considered in the previous sections, an increase in \( \varepsilon_t \) can easily lead to a fall in the relative price of good 2. This occurs in three out of the four scenarios considered in the previous section. It occurs when the unsustainability of monopoly leads to competitive outcomes whether the strategic variable is price or output as long as increases in \( \varepsilon_t \) make monopoly harder to sustain. It also always occurs when the strategic variable is prices and the oligopoly plays an optimal supergame. The decrease in \( P_{2t} \) in turn leads firms in the first sector to demand more of good 2 as an input and to increase their output. So, a shift in demand towards the oligopolistic goods raises all outputs much as all outputs move together during business cycles.

A number of comments deserve to be made about this model of business cycles. First our assumption that the real wage in terms of good 1 is constant does not play an important role. In equilibrium the reduction in \( P_{2t} \) raises real wages thus inducing workers to work more even if they have an
upwardly sloping supply schedule for labor. Whether this increased supply of labor would be sufficient to meet the increased demand for employees by sector 2 is unclear. If it wasn't, the wage would have to rise in terms of good 1. More interestingly if the increased supply of labor was large, $P_{it}$ would have to rise thus increasing employment also in sector 1. This would lead to an expansion even if good 2 was not an input into good 1. This pattern of price movements is consistent with the evidence on the correlation between product wages and employment presented below.

Second, the model can easily be made consistent with the procyclical variation of profits. Even though sector 2 reduces the margin between price and marginal cost as output expands, the difference between revenues and total costs can increase as long as there are fixed costs.

Third, the analysis leaves unexplained the causes of the shifts in sectoral demands. To make sense of actual business cycles, within the context of the models described here, one would have to relate these shifts in demand to changes in the money supply and interest rates which are highly correlated with cyclical fluctuations. Increases in the money stock might be associated with lower interest rates and a higher demand for durable goods. As shown below, durable good industries appear to be more concentrated than other industries. While the connection between financial variables and shifts in demand is beyond the scope of this paper, it must be noted that such shifts form part of the popular discussion of the early stages of recoveries. At that point consumers desire for cars and other durables picks up.

Random shifts in demand have already been shown to cause movements in employment in the asymmetric information model of Grossman, Hart and Maskin (1983). However, contrary to the claims of Lilien (1982) such random
sectoral shifts do not appear to be correlated with aggregate fluctuations. Abraham and Katz (1984) show that different sectors only have distinct correlations with aggregate output. Moreover the sectors whose output is more correlated with aggregate output appear to have a lower rate of growth on average. This leads to the statistical illusion that when output grows faster, as in a recovery, there is less intersectoral variance in output growth than when output growth is small, as in a recession. Note that Abraham and Katz's finding that some sectors are more "cyclic" than others accords well with our theory that shifts towards oligopolistic sectors are necessary to expand aggregate output. This finding also appears to be somewhat at odds with the literature on real business cycles (Long and Flosser (1983) and King and Flosser (1984)). In this literature expansions are caused by favorable unobservable technological shocks. Aside from the fact that there is no independent evidence for the importance of these shocks and that they do not appear in the casual discussions of the people who are directly affected by business cycles it is somewhat peculiar that these favorable shocks always recur in the same "cyclic" industries.16

Our model also sheds light on some slightly unfashionable concepts of Keynesian economics. One of the most pervasive facts about increases in the money supply is that they are not accompanied by equiproportional increases in prices. Prices appear to be sticky (cf Rotemberg (1982)). Suppose that increases in \( \varepsilon \) are correlated with increases in the money supply. Then increases in output are correlated with increases in the money supply. As long as increases in output raise the demand for real money balances, increases in the money supply will be correlated with increases in real money balances. Prices do not rise equiproportionately. A second concept we can usefully discuss in the context of our model is that of a multiplier. This
concept reflects the idea that increases in demand lead output to rise which then leads to further increases in demand. Here a shift in demand towards an oligopolistic sector can raise that sector's output, lower its prices and thus raise national income. In turn this increased national income can lead to increases in the demand for other goods produced in other oligopolistic markets thus lowering their prices and raising their output as well.

IV. SOME RELEVANT FACTS

a) The folklore

The theory presented in section II runs counter to the industrial organization folklore. This folklore is best articulated in Scherer (1980 p. 208) who says: "Yet it is precisely when business conditions really turn sour that price cutting runs most rampant among oligopolists with high fixed costs". Our attempt at finding the facts that support this folklore has, however, been unsuccessful.

Scherer cites three industries whose experience is presented as supporting the folklore: rayon, cement and steel. For rayon he cites a study by Markham (1952) which shows mainly that the nominal price of rayon fell during the Great Depression. Since broad price indices fell during this period this is hardly proof of a price war. Rayon has since been replaced by other plastics making it difficult to use postwar data to check whether any real price cutting took place during postwar recessions. For steel Scherer admits the following: "... up to 1968 and except for some episodes during the 1929-38 depression, it was more successful than either cement or rayon in avoiding widespread price deterioration, even when operating at less than 65% capacity between 1958 and 1962". (p. 210).
This leaves cement. We study the cyclical properties of real cement prices below. We collected data on the average price of portland cement from the Minerals Yearbook published by the Bureau of Mines. We then compare this price with the Producer Price Index and the price index of construction materials published by the Bureau of Labor statistics. Regressions of the yearly rate of growth of real cement prices on the contemporaneous rate of growth of GNP are reported in Table 1.

As the table shows, the coefficient of the rate of growth of GNP is always meaningfully negative. A 1% increase in the rate of growth of GNP leads to a 0.5-1.0% fall in the price of cement. To test whether the coefficients are significant the regression equations must be quasi-differenced since their Durbin-Watson statistics are small. Once this is done we find the coefficients are all significantly different from zero at the five percent level. More casually, the price of cement relative to the index of construction prices rose in the recession year 1954 while it fell in the boom year 1955. Similarly, it rose during the recession year 1958 and fell in 1959. These results show uniformly that the price of cement has a tendency to move countercyclically as our theory predicts for an oligopoly.

These results are of course not conclusive. First, it might be argued that the demand for cement might be only weakly related to GNP. Without a structural model, which is well beyond the scope of this paper, this question cannot be completely settled. The rate of growth of the output of the cement industry has a correlation of .69 with the rate of growth of GNP and of .77 with the rate of growth of construction activity which is well known to be procyclical. However, these correlations are not sufficient to prove that cement is "more procyclical" than the typical sector included in GNP. Second, our regressions do not include all the variables one would expect to see in a
### Table 1

**THE CYCLICAL PROPERTIES OF CEMENT PRICES**

*Yearly Data from 1947 to 1981*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>$p_c/PPI$</th>
<th>$p_c/PPI$</th>
<th>$p_c/p_{con}$</th>
<th>$p_c/p_{con}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coefficient</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>.025 (.010)</td>
<td>.025 (.012)</td>
<td>.038 (.007)</td>
<td>.037 (.008)</td>
</tr>
<tr>
<td>GNP</td>
<td>-.438 (.236)</td>
<td>-.456 (.197)</td>
<td>-.875 (.161)</td>
<td>-.876 (.149)</td>
</tr>
<tr>
<td>$p$</td>
<td>.464 (.173)</td>
<td></td>
<td>.315 (.183)</td>
<td></td>
</tr>
<tr>
<td>$p^2$</td>
<td>.10</td>
<td>.15</td>
<td>.48</td>
<td>.52</td>
</tr>
<tr>
<td>D.W</td>
<td>1.03</td>
<td>1.73</td>
<td>1.28</td>
<td>1.92</td>
</tr>
</tbody>
</table>

$c$ is the price of cement, $PPI$ is the producer price index and $P_{con}$ is the price index of construction materials. Standard errors are in parenthesis.
reduced form. Thus the effect of GNP might be proxying for an excluded variable like the capacity of cement mines. This variable would probably be expected to exercise a negative effect on the real price of cement. It must be pointed out, however, that capacity itself is an endogenous variable which also responds to demand. It would thus be surprising if enough capacity were built in a boom to more than offset the increase in demand. If anything, the presence of costs of adjusting capacity would make capacity relatively unresponsive to increases in GNP.

b) Actual price wars

There have been two recent studies showing that some industries alternate between cooperative and noncooperative behavior. The first is due to Bresnahan (1981). He studies the automobile industry in 1954, 1955 and 1956. He tries to evaluate the different interpretations of the events of 1955. That year production of automobiles climbed by 45% only to fall 44% the following year. Bresnahan formally models the automobile industry as choosing prices each year for a given set of models offered by each firm. He concludes that the competitive model of pricing fits the 1955 data taken by themselves while the collusive model fits the 1954 and 1956 data. Those two years exhibited at best sluggish GNP growth. GNP fell 1% in 1954 while it rose 2% in 1956. Instead 1955 was a genuine boom with GNP growing 7%.17 Insofar as cartels can only sustain either competitive or collusive outcomes, this is what our theory predicts. Indeed, in our model, the competitive outcomes will be observed only in booms.

Porter (1983b) studies the railroad cartel which operated in the 1880's on the Chicago-New York route. He uses time series evidence to show that some weeks were collusive while others were not. He discovers that his results are inconclusive for the theory developed in Green and Porter (1984).
In particular he does not find negative residuals in his demand equation at the beginning of price wars.

We will argue his results support our theory. Table 2 presents the relevant facts. The first three columns are taken from Porter's paper. The first column shows an index of cartel nonadherence estimated by Porter. He shows that this index parallels quite closely the discussions in the Railway Review and in the Chicago Tribune which are reported by Ulen (1978). The second column reports rail shipments of wheat from Chicago to New York. The third column shows the percentage of wheat shipped by rail from Chicago relative to the wheat shipped by both lake and rail. The fourth column presents the national production of grains estimated by the Department of Agriculture. Finally the last column represents the number of days between April 1 and December 31 that the Straits of Mackinac remained closed to navigation. (They were always closed between January 1 and March 31.)

The three years in which the most severe price wars occurred were 1881, 1884 and 1885. Those are also the years in which rail shipments are the largest both in absolute terms and relative to lake shipments. This certainly does not suggest that these wars occurred in periods of depressed demand. However, shipments may have been high only because the railroads were competing even though demand was low. To analyze this possibility we report the values of two natural determinants of demand. The first is the length of time during which the lakes were closed. The longer these lakes remained closed the larger was the demand for rail transport. The lakes were closed the longest in 1881 and 1885. These are also the years in which the index of cartel nonadherence is highest. In 1883 and 1884 the lakes remained closed only slightly less time than in 1885 and yet there were price wars only in 1884. The second natural determinant of demand, total grain
# Table 2

**RAILROADS IN THE 1880's**

<table>
<thead>
<tr>
<th></th>
<th>Estimated Nonadherence</th>
<th>Rail Shipments (Million Bushels)</th>
<th>Fraction Shipped by Rail</th>
<th>Total Grain Production (E billion Tons)**</th>
<th>Days Lakes Closed from 4/1 - 12/31*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>0.00</td>
<td>4.73</td>
<td>22.1</td>
<td>2.70</td>
<td>35</td>
</tr>
<tr>
<td>1881</td>
<td>0.44</td>
<td>7.68</td>
<td>50.0</td>
<td>2.05</td>
<td>69</td>
</tr>
<tr>
<td>1882</td>
<td>0.21</td>
<td>2.39</td>
<td>13.8</td>
<td>2.69</td>
<td>35</td>
</tr>
<tr>
<td>1883</td>
<td>0.00</td>
<td>2.59</td>
<td>26.8</td>
<td>2.62</td>
<td>58</td>
</tr>
<tr>
<td>1884</td>
<td>0.40</td>
<td>5.90</td>
<td>34.0</td>
<td>2.98</td>
<td>58</td>
</tr>
<tr>
<td>1885</td>
<td>0.67</td>
<td>5.12</td>
<td>48.5</td>
<td>3.00</td>
<td>61</td>
</tr>
<tr>
<td>1886</td>
<td>0.06</td>
<td>2.21</td>
<td>17.4</td>
<td>2.83</td>
<td>50</td>
</tr>
</tbody>
</table>

*Obtained from the Chicago Board of Trade Annual Reports.

*This total is constructed by adding the productions of wheat, corn, rye, oats and barley in tons.
production, readily explains the anomalous behavior of 1883. In 1883 total grain production was the second lowest in the entire period and in particular, was 12% lower than in 1884. This might have depressed demand so much that, in spite of the lake closings, total demand for rail transport was low enough to warrant cooperation.

Porter used weekly data instead of our annual aggregates and it might be thought that weekly data provide a stronger basis for accepting or rejecting our theory. However, the price wars roughly followed a seasonal time pattern. The first price war started around January 1881 and lasted for the whole year. The second price war started around January 1884 and ended at the end of 1885. We conjecture that around midwinter agents could form a fairly accurate prediction of the opening of the lakes by studying the thickness of the ice. If they expected the lakes to be closed for a long period they naturally expected a price war to develop. Once the individual railroads predicted a war for the future they were tempted to cut their prices immediately for two reasons. First, the penalties for deviating were reduced since in the future the outcome would be competitive in any event. Second, individuals who had the capacity to store grain would postpone shipments if they knew a price war was imminent thus lowering even the monopoly price.

c) Price-cost margins

One natural test of our theory is whether there is substantial price cutting by oligopolists when demand is high. What is difficult about carrying out this test is that prices must be compared to marginal costs and that data on marginal costs at the firm or even at the industry level is notoriously scarce. Traditionally researchers in Industrial Organization have focused on price-cost margins which are given by sales minus payroll and
material costs divided by sales. This is a crude approximation to the Lerner Index which has the advantage of being easy to compute. Indeed Scherer cites a number of studies which analyzed the cyclical variability of these margins in different industries. These studies have led to somewhat mixed conclusions. However Scherer concludes on p. 357: "The weight of the available statistical evidence suggests that concentrated industries do exhibit somewhat different pricing propensities over time than their atomistic counterparts. They reduce prices (and more importantly) price-cost margins by less in response to a demand slump and increase them by less in the boom phase". This does not fit well with the folklore which would predict that on average prices would tend to fall more in recessions the more concentrated is the industry.

On the other hand our theory can provide an explanation for those facts provided that falling prices relative to marginal costs in booms are consistent with concurrently increasing price-cost margins. To see that these are consistent suppose that labor costs include fixed costs. Then an increase in the hours worked per worker will lower the importance of the fixed labor costs and, ceteris paribus, raise price-cost margins. In that setting the fact that price-cost margins rise less in concentrated than in unconcentrated industries must imply either that the concentrated industries tend to reduce prices relative to marginal cost or that fixed costs are less important in those industries. The latter seems a priori unlikely.

We also study some independent evidence on margins. Burda (1984) reports correlations between employment and real product wages in various two digit industries. These real product wages are given by the average hourly wage paid by the industry divided by the value added deflator for the industry. They can be interpreted as a different crude measure of marginal
cost over prices. Their disadvantage over the traditional price-cost margin is that, unlike the latter, to interpret them this way requires not only that materials be proportional to output but also that materials costs be simply passed through as they would in a competitive industry with this cost structure. On the other hand, their advantage over the traditional measure is that they remain valid when some of the payroll expenditure is a fixed cost as long as, at the margin, labor has a constant marginal product. Moreover it turns out that if the marginal product of labor actually falls as employment rises our evidence provides even stronger support for our theory.

The correlations reported by Burda for the real product wage and employment using detrended yearly data from 1947 to 1978 are reported in Table 3 which also reports the average four firm concentration ratio for each two digit industry. This average is obtained by weighting each four digit SIC code industry within a particular 2 digit SIC code industry by its sales in 1967. These weights were then applied to the 1967 four firm concentration indices for each 4 digit SIC code industry obtained from the Census.
At first glance it is clear from the table that more concentrated industries like motor vehicles and electrical machinery tend to have positive correlations while less concentrated industries like leather, food and wood products tend to have negative correlations. Statistical testing of this correlation with the concentration index is, however, somewhat delicate. That is because our theory does not predict that an industry which is 5% more concentrated than another will reduce prices more severely in a boom. On the contrary a fully fledged monopoly will always charge the monopoly price which usually increases when demand increases. All our theory says is that as soon
as an industry becomes an oligopoly it becomes likely that it will cut prices in booms.

Naturally the concentration index is not a perfect measure of whether an industry is an oligopoly. Indeed printing has a low concentration index even though its large components are newspapers, books and magazines which are in fact highly concentrated once location in space or type is taken into account. Nonetheless higher concentration indices are at least indicators of a smaller number of important sellers. Glass is undoubtedly a more oligopolistic industry than shoes. So we decided to classify the sample into relatively unconcentrated and relatively concentrated and chose, somewhat arbitrarily, as the dividing line the median concentration of 35.4. This lies between food and nonelectrical machinery. We can then construct the following 2X2 contingency table:

<table>
<thead>
<tr>
<th></th>
<th>Unconcentrated</th>
<th>Concentrated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negatively</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>correlated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positively</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>correlated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

An alternative table can be obtained by neglecting the three observations whose correlations are effectively zero. These are sectors 22, 28 and 372-9. Their correlations are at most equal in absolute value to a
third of the next lowest correlation. Then the contingency table has, instead of the values 7:3:3:7, the values 7:2:2:6.

It is now natural to test whether concentrated and unconcentrated industries have the same ratio of positive correlations to negative ones against the alternative that this ratio is significantly higher for concentrated industries. The $\chi^2$ test of independence actually only tests whether the values are unusual under the hypothesis of independence without focusing on our particular alternative. It rejects the hypothesis of independence with 92% confidence using the values of Table 4 and with 97% confidence using the values 7:2:2:6. This test is, however, likely to be flawed for the small sample we consider. Fisher's test would appear more appropriate since it is an exact test against the alternative that more concentrated sectors have more positive correlations. With this test the hypothesis that the ratio of positive correlations is the same can be rejected with 91% confidence using the data of Table 4 and with 96% confidence using 7:2:2:6.

These regularities should be contrasted to the predictions of the standard theory of labor demand. In this theory employment rises only when the real product wage falls. This occurs in both monopolistic and competitive industries as long as there are diminishing returns to labor. Therefore the finding that the product wage rises when employment rises suggests the widespread price-cutting our theory implies.

There is an alternative classical explanation for our findings. This explanation relies on technological shocks. These shocks can, in principle either increase or decrease the demand for labor by a particular sector. If they increase the demand and the sector faces an upwards sloping labor supply function, employment and real wages can both increase. The difficulty with
this alternative explanation is that the sectors with positive correlations
do not appear to be those which a casual observer would characterize as
having many technological shocks of this type. In particular, stone, clay
and glass, printing and publishing and rubber appear to be sectors with
fairly stagnant technologies. On the other hand instruments and chemicals may
well be among those whose technology has been changing the fastest.

V. CONCLUSIONS

The data we study show moderate support for the theories developed in
this paper. This suggests that both the theories and their empirical
validation deserve to be extended.

The theory of oligopoly might be extended to include also imperfectly
observable demand shifts, prices and outputs of the type studied by Green
and Porter (1984). The advantage of introducing unobservable shifts in
demand is that these can induce reversions to punishing behavior even when
all firms are acting collusively. A natural question to ask is whether
reversions to punishing behavior that result from unobservable shocks are
more likely when everybody expects the demand curve to have shifted out.
Unfortunately this appears to be a very difficult question to answer. Even
the features of the optimal supergame without observable shocks discussed in
Porter (1985a) are hard to characterize. Adding the complication that both
the length of the punishment period as well as the price that triggers a
reversion depend on observable demand is a formidable task.

In this paper we considered only business cycles which are due to the
tendency of oligopolists to act more competitively when demand shifts towards
their products. An alternative and commonly held view is that business
cycles are due to changes in aggregate demand which do not get reflected in
nominal wages. In that case a decrease in aggregate demand raises real wages thereby reducing all outputs. In our theory of oligopoly, firms tend to collude more in these periods. Hence recessions are not only bad because output is low but also because microeconomic distortions are greater. This suggests that stabilization of output at a high level is desirable because it reduces these distortions.

On the other hand, the business cycles discussed here do not necessarily warrant stabilization policy. While models of real business cycles merely feature ineffective stabilization policies here such policies might actually be harmful. Booms occur because, occasionally, demand shifts towards oligopolistic products. In these periods the incentive to deviate from the collusive outcome is greatest because the punishment will be felt in periods which, on average, have lower demand and hence lower profits. If instead future demand were also known to be high, the threat of losing the monopoly profits in those good periods might well be enough to induce the members of the oligopoly to collude now. So, if demand for the goods produced by oligopolies were stable they might collude always, leaving the economy in a permanent recession. Therefore the merits of stabilization policy hinge crucially on whether business cycles are due to shifts in demand unaccompanied by nominal rigidities or whether they are due to changes in aggregate demand accompanied by such rigidities. Disentangling the nature of the shifts in the demand faced by oligopolies therefore seems to be a promising line of research.

Much work also remains to be done empirically validating our model itself. In section IV we presented a variety of simple tests capable of discriminating between the Industrial Organization folklore and our theory. Since none of them favored the folklore it may well be without empirical
content. On the other hand, our theory deserves to be tested more severely. First a more disaggregated study of the cyclical properties of price-cost margins seems warranted. Unfortunately, data on value added deflators does not appear to exist at a more disaggregated level so a different methodology will have to be employed. Second our theory has strong implications for the behavior of structural models of specific industries. The study of such models ought to shed light on the extent to which observable shifts in demand affect the degree of collusion.

Finally, our theory can usefully be applied to other settings. Consider, in particular, the game between countries as they set their tariffs. In standard models unilateral tariffs may be desirable either as devices to exercise monopsony power or, with fixed exchange rates, to increase employment. The noncooperative outcome in a game between the countries may have very little international trade. In a repeated game more international trade can be sustained by the threat to curtail trade further. If unilateral trade barriers become more attractive in recessions (because the gains in employment they induce are valued more) the equilibrium will have trade wars in states of depressed demand.
FOOTNOTES

1 If firms find borrowing difficult, recessions might be the ideal occasions for large established firms to elbow out their smaller competitors.

2 There are also two alternative reasons why prices may be lower when demand is high. First, firms may be charging the monopoly price in the face of short run increasing returns to scale. The existence of such increasing returns strike us as unlikely. When production is curtailed this is usually done by temporary closings of plants or reductions of hours worked. These reductions would always start with the most inefficient plants and workers thus suggesting at most constant returns to labor in the short run. Second, as argued by Stiglitz (1984) using a setup similar to the incomplete information limit pricing model of Milgrom & Roberts (1982), limit pricing may be more salient in booms if the threat of potential entry is also greater at that time.

3 See, for example, Friedman (1971), Green and Porter (1984) and Radner (1980).

4 Sequentially rational strategies are analyzed in games of incomplete information by Kreps and Wilson (1982). For the game of complete information that we analyze we use Selten's concept of subgame perfection (1965).

5 When quantities are the strategic variable, Abreu (1982) shows that punishments can be more severe while still being credible. However he requires that firms who defect from the punishment be punished in turn and so on. This considerably complicates the analysis.

6 In informal discussions, Abramowitz (1948) and Kurz (1979) recognize the link between short-run profitability and the sustainability of collusive outcomes. However, the relationship between profits, demand, and costs is not made explicit.

7 Note that \( P = c \) is the highest possible punishment for the oligopoly. If \( P \) is below \( c \) firms make losses and will choose not to participate.

8 An infinite punishment period and low value of \( \delta \) is only equivalent to a finite punishment period and high value of \( \delta \) if the length of the punishment is independent of \( \varepsilon_t \).

9 If, instead, the length of the punishment did depend on \( \varepsilon_t \), naturally \( K \) would depend on \( \varepsilon_t \) as well.

10 See Maskin (1984) for a proof that a mixed strategy equilibrium exists.

11 In this case an increase in \( \varepsilon_t \) can directly be interpreted as either a shift outwards in demand or a reduction in \( c \), that part of marginal cost which is independent of \( q \). This results from the fact that the profit functions depend on \( \varepsilon_t \) only through \( a + \varepsilon_t - c \).
In order to do this, however, the profits accruing to firms during the punishment period must be calculated. Rather than attempting to solve for the mixed strategy equilibria we used the profits corresponding to price equal to marginal cost. In fact those profits are lower than in the mixed strategy equilibrium which means that actual punishments are less severe than we have assumed. However, as we show below, even in that case monopoly is often sustainable only in states of low demand. In any case, the qualitative features of the model are unaffected by this assumption, only the actual value of $c^*_t$ is affected.

Business cycles are persistent and thus cannot adequately be modeled as resulting from the i.i.d. shifts considered in previous sections. However, what is necessary for prices to be low when demand is high is only that the punishments for deviating be carried out mostly in states of lower demand. This is likely to happen even if demand follows a fairly general stationary process.

The intersectoral pattern of output movements can be independent of the sector which has a technological shock if (as seems unlikely) goods are consumed in fixed proportions which depend on the level of utility only. Otherwise "normal" substitution effects will make the expansion biggest in the sector which has the most favorable technological shock.

It must be noted that the focus of Bresnahan's study is the 1955 model year which doesn't coincide with the calendar year. Nonetheless his data on prices corresponds to April 1955. By that time the boom was well under way.

When constructing these aggregate concentration indices we systematically neglected the 4 digit SIC code industries which ended in 99. These contain miscellaneous or "not classified elsewhere" items whose concentration index does not measure market power in a relatively homogeneous market.

For the examples in Figures 3 and 4 this occurs as long as $\delta > 0.8$ when price is the strategic variable or $\delta > 0.25$ when quantities are the strategic variable.
References


