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Author(s): Julio J. Rotemberg and Garth Saloner

Source: *The American Economic Review*, Jun., 1986, Vol. 76, No. 3 (Jun., 1986), pp. 390–407

Published by: American Economic Association

Stable URL: https://www.jstor.org/stable/1813358

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A Supergame-Theoretic Model of Price Wars during Booms

By JULIO J. ROTEMBERG AND GARTH SALONER*

This paper explores the response of oligopolies to fluctuations in the demand for their products. In particular, we argue on theoretical grounds that implicitly colluding oligopolies are likely to behave more competitively in periods of high demand. We then show that, in practice, during those periods, various oligopolistic industries tend to have relatively low prices. The few price wars which have been documented also seem to have taken place during periods of high demand. Finally, we study the possibility that this oligopolistic behavior has macroeconomic consequences. 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.

We examine implicitly colluding oligopolies of the type introduced by James 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 Robert 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 that maximizes joint profits is larger. A firm that 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 variables 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

*Sloan School of Management and Department of Economics, MIT, Cambridge, MA 02139, respectively.

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.

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 view is articulated for example in F. M. Scherer (1980). Our basis for questioning it is not only theoretical. Indeed, it is possible to construct models in which recessions induce price wars.[1,2] In a model with imperfect observability of demand, Edward 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.

Whether competition is more pervasive in booms or busts is an empirical question. While we do not conclusively settle this empirical issue, a brief analysis of some related facts seems to provide more support for our theory than for the industrial organization folklore.

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. Second, more specifically, we find that both Scherer's evidence and our own study of the cyclical properties of price-cost margins are consistent with our theory. The ratio of prices to our measure of marginal cost tends to be countercyclical in more concentrated industries. Also the price wars purported to have happened in the automobile industry (Timothy Bresnahan, 1981) and the railroad industry (Porter, 1983a) occurred in periods of high demand. Finally, since Scherer singles out the cement industry as having repeated breakups 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.

Up to this point we have focused on the effect of changes in demand like those that could be induced by business cycles on oligopolistic sectors. We go on to examine whether these oligopolistic responses to changes in demand themselves have aggregate consequences. In particular, we consider the general equilibrium effects of a shift in demand towards an oligopolistic sector. We show that in a very simplified two-sector model, the ensuing reduction in the oligopoly's price can lead the other sector to raise its output as well. This occurs in our model because the other sector, which is competitive, uses the oligopoly's output as an input.

The paper proceeds as follows. Section I presents our theory of oligopoly under fluctuating demand. Section II contains the empirical regularities which lend some plausibility to our theory. Section III considers the general equilibrium model which forms the basis of our discussion of macroeconomics, and conclusions are drawn in Section IV.

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[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 Joseph Stiglitz (1984) using a setup similar to the incomplete information limit pricing model of Paul Milgrom and John Roberts (1982), limit pricing may be more salient in booms if the threat of potential entry is also greater at that time.

I. 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, then 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 nondefecting firms are willing to mete out the proposed punishment. A simple and often employed way (see Green and Porter, 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.[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 write the inverse demand function as $P(Q_t, \varepsilon_t)$ where Q_t is the industry output in period t and ε_t is the realization at t of $\tilde{\varepsilon}$, the random variable denoting the observable demand shock. We assume that P is increasing in ε_t, that $\tilde{\varepsilon}$ has domain $[\underline{\varepsilon}, \bar{\varepsilon}]$ and a distribution function $F(\varepsilon)$, and that these are the same across periods (i.e., shocks are independently and identically distributed). 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 each period, all firms learn the realization of $\tilde{\varepsilon}$ (more precisely ε_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 ε_t and the key to the difference between the model and its predecessors is the following: the punishments that firms face depend on future realizations of $\tilde{\varepsilon}$. The expected value of such punishments therefore depends on the expected value of $\tilde{\varepsilon}$. However, the reward for cheating in any period depends on the observable ε_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 ε_t. If ε_t is large enough, the temptation to cheat outweighs the punishment.[6] The observability of ε_t allows the oligopoly to recognize this fact. Thus an implicitly colluding oligopoly may

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[3] See, for example, Friedman, Green and Porter, and Roy Radner (1980).

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

[5] When quantities are the strategic variable, Dilip 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, Moses Abramowitz (1938) and Mordecai 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.

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. Prices as Strategic Variables

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 ε_t. Figure 1 shows the profits of each firm, Π, as a function of the aggregate output, Q_t, for a variety of values of ε_t. These profit loci are drawn assuming each firms supplies $1/N$ of Q_t. As ε_t increases, the price for each Q_t rises so that profits are increasing in ε_t. The term $\Pi^m(\varepsilon_t)$ denotes the profit of an individual firm in state ε_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 ε_t since profits are increasing in ε_t even holding Q_t constant.

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

(1) $$N\Pi^m(\varepsilon_t) - K > \Pi^m(\varepsilon_t)$$
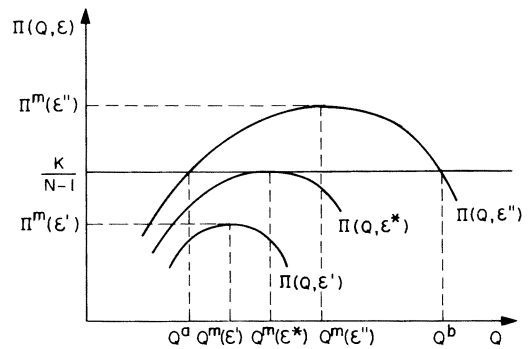

FIGURE 1. PROFITS OF THE OLIGOPOLY

that is, if

$$\Pi^m(\varepsilon_t) > K/(N-1),$$

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 ε_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 ε_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 ε_t is below and above ε_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,

(2) $$\Pi^s(\varepsilon_t, \varepsilon_t^*)$$

$$= \begin{cases} \Pi^m(\varepsilon_t) & \text{for } \varepsilon_t \leq \varepsilon_t^* \\ \Pi^m(\varepsilon_t^*) = \dfrac{K}{N-1} & \text{for } \varepsilon_t > \varepsilon_t^*. \end{cases}$$

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 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 "irritational" emotion, may be short-lived.

The presence of relatively short punishments is important to our analysis because they make K low. Otherwise the inequality in (1) is always satisfied, that is, 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 ε_t if firms are fairly committed to their current prices as they would be if adjusting prices were costly.

While short periods of punishment are realistic, infinite punishments are simpler. Thus we actually use infinite punishments and capture their relatively small importance by assuming that δ, the factor used to discount future profits, is small.[8] 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

$$(3) \qquad K = \frac{\delta}{1-\delta} \int_{\underline{\varepsilon}}^{\bar{\varepsilon}} \Pi^s(\varepsilon, \varepsilon_t^*) \, dF(\varepsilon).$$

Even if we allow K to depend on ε_t, the right-hand side of (2) is independent of ε_t. Therefore the punishment is indeed independent of the state.[9] Using (2) we can rewrite equation (3) as

$$(4) \quad K(\varepsilon_t^*) = \frac{\delta}{1-\delta} \left[\int_{\underline{\varepsilon}}^{\varepsilon_t^*} \Pi^m(\varepsilon) \, dF(\varepsilon) \right.$$
$$\left. + (1 - F(\varepsilon_t^*)) \Pi^m(\varepsilon_t^*) \right].$$

This gives a mapping from the space of possible punishments into itself: a given punishment implies a cutoff ε_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, that is, to show there exists an $\varepsilon^* \in (\underline{\varepsilon}, \bar{\varepsilon})$ for which (2) and (4) hold. Let ε_t' be a candidate for such an ε_t^* and define

$$(5) \quad g(\varepsilon_t') = \Pi^m(\varepsilon_t') - K(\varepsilon_t')/(N-1).$$

We need to show there exists an $\varepsilon_t' \in (\underline{\varepsilon}, \bar{\varepsilon})$ such that $g(\varepsilon_t') = 0$. Using (4) and (5):

$$g(\underline{\varepsilon}) = \Pi^m(\underline{\varepsilon}) \left(1 - \frac{\delta}{(1-\delta)(N-1)} \right)$$

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[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 δ is only equivalent to a finite punishment period and high

value of δ if the length of the punishment is independent of ε_t.

[9] If, instead, the length of the punishment did depend on ε_t, naturally K would depend on ε_t as well.

which is negative if

$$(6) \qquad N < 1/(1-\delta).$$

In other words, for N small enough relative to the discount factor δ, 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 (δ smaller), the punishments become less important and (6) fails.

On the other hand:

$$g(\bar{\varepsilon}) = \Pi^m(\bar{\varepsilon}) - \delta/((N-1)(1-\delta))$$

$$\times \int_{\underline{\varepsilon}}^{\bar{\varepsilon}} \Pi^m(\varepsilon)\, dF(\varepsilon)$$

which is positive if

$$(7) \quad \Pi^m(\bar{\varepsilon})/\int_{\underline{\varepsilon}}^{\bar{\varepsilon}} \Pi^m(\varepsilon)\, dF(\varepsilon)$$

$$> \delta/[(1-\delta)(N-1)].$$

This condition ensures that the monopoly outcome is not the only solution in every state. This holds when there is sufficient dispersion in the distribution of profit-maximizing outputs. If there is no dispersion, the left-hand side of (7) equals one. Then (7) becomes $N > 1/(1-\delta)$, the opposite of (6). So, in the absence of dispersion, if (6) holds there is never any incentive to cheat. When there is some dispersion, the left-hand side of (7) exceeds one, making it possible for (6) and (7) to hold simultaneously.

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

This equilibrium has several interesting features. In particular, for $\varepsilon_t > \varepsilon^*_t$ it can be shown that the higher is demand (the higher is ε_t), the higher is equilibrium output and the lower is the equilibrium price. When ε_t exceeds ε^*_t, $\Pi^s = Q_t(P_t - c)$ 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_t^b in Figure 1 and not at Q_t^a. Otherwise a deviat-

ing firm can earn more than $N\Pi^s$ by cutting its price.

Since output is above Q_t^m, 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 ε_t rises since P_t is larger. Therefore an increase in ε_t must be accompanied by an increase in Q_t. Since increases in ε_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 δ decreases, ε^*_t falls. In both cases, the gains from cheating rise relative to cooperative profits, 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 $g(\bar{\varepsilon})$ is positive ensures that g is increasing in ε at the largest value of ε' for which $g(\varepsilon') = 0$. Second, for fixed Q_t and ε_t, the profits of a single firm are one-Nth of the total profits of the industry. Thus, for a fixed ε^*_t, equation (4) implies that K and $\Pi^m(\varepsilon^*_t)$ are inversely proportional to N. Therefore, increases in N raise g since they raise $\Pi^m(\varepsilon^*_t)$ relative to $K/(N-1)$, that is, the temptation to cheat increases. Similarly, a decrease in δ raises g since K falls. Finally, the increases in g brought about either by an increase in N or a reduction in δ implies that ε^*_t must fall to restore equilibrium.

As 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. 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, ε_t^*, that delineates the cooperative and non-cooperative regions. In contrast to the optimal model, however, the graph of price as a function of state will exhibit a sharp decline after ε_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 $\Pi^d(\varepsilon_t, P) > \Pi^s(\varepsilon_t) + K$, where Π^d is the profit to the firm that defects when its opponents charge P. However, Π^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.[10]

A number of results can nonetheless be demonstrated for an example in which demand and marginal costs are linear:[11]

(8) $P = a + \varepsilon_t - bQ_t$,

(9) $c(q_{it}) = cq_{it} + dq_{it}^2/2$.

It is straightforward to show that in this example, cheating becomes more desirable as ε_t rises.[12] So, as before, if the oligopoly is restricted to either collude or compete, high ε_t's generate price wars. Alternatively the oligopoly can pick prices P^s which just deter potentially deviating firms. These prices equate Π^s, the profits from going along, with $\Pi^d - K$ where K is the expected present value of Π^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, Π^s, and the profit to a deviating firm, Π^d, are quadratic in P^s, this involves solving a quadratic equation. The relevant root is the one that yields the highest value of Π^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 us to calculate a new value for K: the one that corresponds to the calculated P^s's.[13] We 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
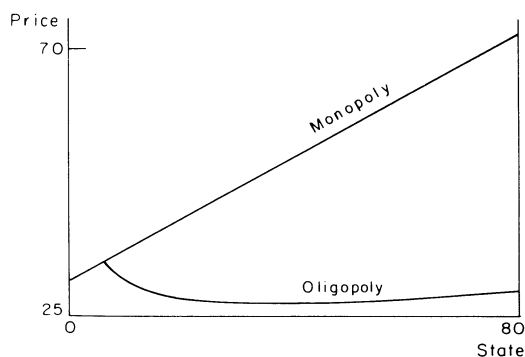

FIGURE 2. PRICES AS STRATEGIC VARIABLES
Parameters: $a = 60$, $b = 1$, $c = 0$, $d = 1/3$,
$\delta = 0.7$, $N = 5$

FIGURE 3. THE INCENTIVE TO DEVIATE WITH
QUANTITIES AS STRATEGIC VARIABLES

of parameters. In particular ε_t is uniformly distributed over $\{0, 1, \ldots, 80\}$.

As before, the price rises monotonically to ε_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 ε_t, a firm that deviates by shading its price slightly is unwilling to supply all 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
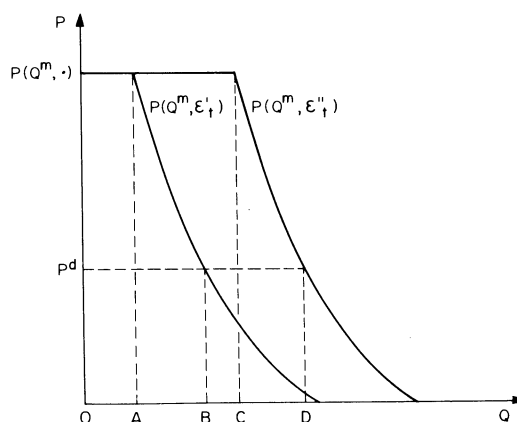
the outcome in punishment periods is the Cournot equilibrium.

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 show that when demand and marginal costs are linear, this is the case. We also show with that 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 demand in states ε_t' and ε_t'' 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 the maximum profits

are achieved at output D and price P^d for state ε_t''. 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 $P(Q^m, \cdot)$ to P^d. But (except for a horizontal translation) the firm faces the same residual demand curve in both states. Thus by selling at P^d, the extra sales due to cheating are the same at $\varepsilon_t'(AB)$ as at $\varepsilon_t''(CD)$. Moreover the loss in revenue on old sales is strictly smaller at ε_t'. Therefore the firm has a strictly greater incentive to deviate in state ε_t' than in state ε_t''.

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 ε_t increases (thus supplying all the increased demand), the incentive to cheat is reduced when demand shifts horizontally. This is why the oligopoly is always able to increase the price as the state improves.

Now consider the case in which demand and marginal costs are linear as in (8) and (9). There an increase in ε_t always leads to a bigger incentive to deviate from the collusive output.[14] As in the previous subsection, 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 analagous 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 ε_t. While the equilibrium price rises as ε_t rises, it can be seen that beyond a certain ε_t the ratio of equilibrium price to monopoly price falls monotonically.

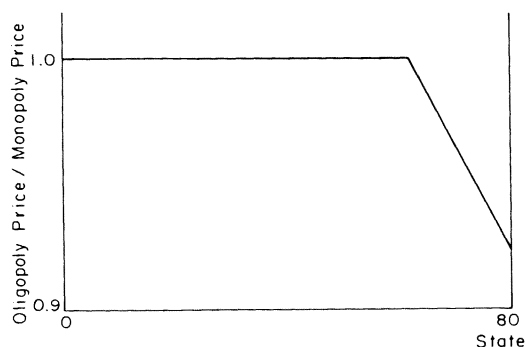[14] The proof of this is also contained in the appendix available on request.

FIGURE 4. QUANTITIES AS STRATEGIC VARIABLES
Parameters: $a = 60$, $b = 1$, $c = 0$, $d = 1/3$,
$\delta = 0.7$, $N = 5$

II. A Survey of Related Empirical Findings

The theory presented in the previous section runs counter to the industrial organization folklore. This folklore is best articulated in Scherer, who says: "Yet it is precisely when business conditions really turn sour that price cutting runs most rampant among oligopolists with high fixed costs" (p. 208).

Given the pervasiveness of this folklore, it is incumbent upon us to at least provide some fragments of evidence which are consistent with our theory. There are at least three kinds of data capable of shedding light on whether prices tend to be low in concentrated industries when their demand is high. First, there is the cyclical pattern of prices in concentrated industries relative to other prices. We can see whether these relative prices tend to be pro- or countercyclical. Second, a similar analysis can be applied to the cyclical pattern of prices in concentrated industries relative to their costs. Finally, there are the documented episodes of price wars. Here what is relevant is whether they occurred in periods of high or low demand. In this section, we reexamine existing data of all three types. It must be pointed out at the outset, however, that this analysis is not a direct empirical test of the model itself, but only a cursory analysis of its most striking implication. The need for such direct tests is suggested by our findings since they largely bear out this implication.

TABLE 1—THE CYCLICAL PROPERTIES OF CEMENT PRICES
(Yearly Data from 1947 to 1981)[a]

Coefficient	Dependent Variable			
	P^c/PPI	P^c/PPI	P^c/P^{con}	P^c/P^{con}
Constant	.025	.025	.038	.037
	(.010)	(.012)	(.007)	(.008)
GNP	−.438	−.456	−.875	−.876
	(.236)	(.197)	(.161)	(.149)
ρ		.464		.315
		(.173)		(.183)
R^2	.10	.15	.48	.52
D-W	1.03	1.73	1.28	1.92

[a] P^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 shown in parentheses.

A. The Cyclical Properties of Cement Prices

Scherer cites three industries whose experience is presented as supporting the folklore: rayon, cement and steel. For rayon he cites a study by Jesse 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 materials 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% of 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* (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 percent increase in the rate of growth of *GNP* leads to a 0.5–1.0 percent fall in the price of cement. To test whether the coefficients are significant, the regression equations must be quasi differenced since their Durbin-Watson (*D-W*) statistics are small. Once this is done we find the coefficients are all significantly different from zero at the 5 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 is possible that increases in *GNP* lower the demand for cement relative to that for other goods. Without a structural model, which is well beyond the scope of this paper, this question cannot be completely settled. However, 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. Second, our regressions do not include all the variables one would expect to see in a 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. *The Cyclical Properties of Price-Cost Margins*

In the industrial organization literature there have been a number of studies that have attempted to measure the cyclical variations in price-cost margins. Usually these are measured 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: "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" (p. 357). 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, a recent paper by Ian Domowitz, Glenn Hubbard, and Bruce Petersen (1986a) finds more procyclical movements of price-cost margins in concentrated industries.

Price-cost margins can only be interpreted as the Lerner Index if labor costs are proportional to output. However, there is a large fixed component to labor costs. Thus when output rises, the ratio of labor costs to revenues falls and, *ceteris paribus*, price-cost margins rise. Therefore, if the fixed labor cost tends to be higher in concentrated industries, one expects to find their price-cost margins to be relatively procyclical.

We therefore also study some independent evidence on margins. Michael Burda (1984) reports correlations between employment and real product wages in various 2-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 in 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 2, which also reports the average four-firm concentration ratio for each 2-digit industry. This average is obtained by weighting each 4-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.[15]

At first glance it is clear from Table 2 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

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[15] 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.

TABLE 2—CONCENTRATION AND THE CORRELATION
BETWEEN REAL WAGES AND EMPLOYMENT

SIC Number	Industry Designation	Corre-lation	Concen-tration
Durables Manufacturing			
24	Lumber and Wood Products	−.33	17.6
25	Furniture and Fixtures	−.18	21.6
32	Stone, Clay and Glass	.39	37.4
33	Primary Metals	.32	42.9
34	Fabricated Metal Industries	.23	29.1
35	Machinery except Electrical	.12	36.3
36	Electrical and Electronic Equipment	.34	45.0
371	Motor Vehicles and Equipment	.19	80.8
372–9	Other Transportation Equipment	.02	50.1
38	Instruments and Related Products	−.36	47.8
Nondurables Manufacturing			
20	Food and Kindred Products	−.30	34.5
21	Tobacco Manufactures	−.64	73.6
22	Textile Mill Products	.04	34.1
23	Apparel and Related Products	−.53	19.7
26	Paper and Allied Products	−.42	31.2
27	Printing and Publishing	.40	18.9
28	Chemical and Allied Products	−.03	49.9
29	Petroleum and Coal Products	−.48	32.9
30	Rubber	.16	69.1
31	Leather and Leather Products	−.44	24.5

TABLE 3—CONCENTRATION/CORRELATION
CONTINGENCY TABLE

	Unconcentrated	Concentrated	Total
Negatively Correlated	7	3	10
Positively Correlated	3	7	10
Total	10	10	20

concentration index is, however, somewhat delicate. That is because our theory does not predict that an industry which is 5 percent 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 that 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 classify the sample into relatively unconcentrated and relatively concentrated and choose, somewhat arbitrarily, as the dividing line the median concentration of 35.4. This lies between food and nonelectrical machinery. Table 3 is the resulting 2×2 contingency 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 one-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 χ^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 percent confidence using the values of Table 3 and with 97 percent 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 percent confidence using the data of Table 3 and with 96 percent confidence using $7:2:2:6$.[16]

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 upward-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.

C. *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, and attempts to evaluate the different interpretations of the events of 1955. That year production of automobiles climbed by 45 percent only to fall 44 percent 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 percent in 1954 while it rose 2 percent in 1956. Instead, 1955 was a genuine boom with *GNP* growing 7 percent.[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.

We present some of his findings in the first three columns of Table 4. 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 Thomas 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

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[16] These results are consistent with evidence by Domowitz, Hubbard, and Petersen (1986b) which shows that value-added deflators tend to be more countercyclical in concentrated industries.

[17] 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 correspond to April 1955. By that time the boom was well under way.

TABLE 4—RAILROADS IN THE 1880'S

	Estimated Nonadherence	Rail Shipments (Million bushels)	Fraction Shipped by Rail	Total Grain Production (Billion Tons)[a,b]	Days Lakes Closed 4/1–12/31[a]
1880	0.00	4.73	22.1	2.70	35
1881	0.44	7.68	50.0	2.05	69
1882	0.21	2.39	13.8	2.69	35
1883	0.00	2.59	26.8	2.62	58
1884	0.40	5.90	34.0	2.98	58
1885	0.67	5.12	48.5	3.00	61
1886	0.06	2.21	17.4	2.83	50

[a] Obtained from the Chicago Board of Trade (1880–86).
[b] This total is constructed by adding the productions of wheat, corn, rye, oats, and barley in tons.

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 the 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 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 percent 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.[18]

[18] Our analysis uses annual aggregates rather than the weekly data used by Porter. As the estimate of cartel nonadherence in Table 2 shows, however, the price wars in 1881, 1884, and 1885 did not last the entire year. Indeed, in each of those years there were at least two separate episodes of price wars. Using only annual data we are unable to show that each of the price wars occurred during a high demand period. Some relevant evidence is provided in a more recent study by Porter (1985). There, using weekly data, he finds that price

In summary, the years in which the cartel was unable to collude effectively were also years in which demand seems to have been high.

III. General Equilibrium Consequences

So far we have considered only the behavior of an oligopoly in isolation. To study the aggregate consequences of this behavior, we need to model the rest of the economy. We consider a 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 with various combinations of labor and good 2. In particular the industrywide production function of good 1 is given by

$$(10) \quad Q_{1t} = \alpha Q_{21t} - \frac{\beta Q_{21t}^2}{2} + \gamma L_{1t} - \frac{\xi L_{1t}^2}{2}$$

wars were more likely to occur in any period the larger the quantity sold in the previous period. This suggests that price wars tended to begin when firms expected unusually high demand.

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:

$$(11) \qquad L_{1t} = (\gamma - 1)/\xi,$$

$$(12) \qquad P_{2t} = \alpha - \beta Q_{21t}.$$

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

$$P_{2t} = n - m Q_{2ct} + e_t,$$

where Q_{2ct} is the quantity of good 2 purchased by consumers, n and m are parameters, and e_t is an independently and identically distributed random variable. Therefore total demand for good 2 is given by

$$(13) \qquad P_{2t} = a + \varepsilon_t - b Q_{2t},$$

$$a = (n\beta + m\alpha)/(m + \beta),$$

$$\varepsilon_t = e_t \beta/(m + \beta),$$

$$b = m\beta/(m + \beta).$$

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

$$L_{2t} = c Q_{2t} + (d/2) Q_{2t}^2,$$

which implies that, as before, marginal cost is $c + d Q_{2t}$. 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:

$$Q_{2t}^c = (a + \varepsilon_t - c)/(b + d),$$

$$P_{2t}^c = ((a + \varepsilon_t)d + bc)/(b + d).$$

An increase in ε_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 ε_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 ε_t can easily lead to a fall in the relative price of good 2.[19] This occurs in three out of the four scenarios considered in Section I. It occurs when the unsustainability of monopoly leads to competitive outcomes whether the strategic variable is price or output as long as increases in ε_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.[20]

A number of comments deserve to be made about this model. 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 upward-sloping supply sched-

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[19] This fall in the price of a good in response to an increase in its demand would also characterize industries with increasing returns to scale which, for some reason, equated price to average costs.

[20] Business cycles are persistent and thus cannot adequately be modeled as resulting from the independently and identically distributed 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.

ule for labor. Whether this increased supply of labor would be sufficient to meet the increased demand for employees by sector 2 in 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_{1t} 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 in Section II.

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. 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' desires for cars and other durables picks up.

Our model exhibits a variety of somewhat Keynesian features. First, changes in aggregate output are related to fluctuations in demand and not, unlike in classical models, to changes in supply conditions such as productivity or labor supply.[21] Second, the model has the potential for providing an

explanation for the stickiness of prices discussed, for example, in Rotemberg (1982). Suppose that increases in ε_t 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. Third, we can discuss the multiplier in the context of our model. 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. 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 studies by Green and Porter. 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 (1983a) 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.

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[21] Keynesian models usually focus on changes in "aggregate demand" whereas our model hinges on changes in relative demand. However, in practice, when households demand more, they demand disproportionately more from certain oligopolistic sectors such as the consumer durables sector. Therefore, the distinction between the two types of changes in demand may not be very important.

In this paper we considered only business cycles that 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 that, 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.[22] 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 oligolopies therefore seems to be a promising line of research.

Much work also remains to be done empirically validating our model itself. In Section II 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 do 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.

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[22] For the examples in Figures 3 and 4, this occurs as long as $\delta \geq 0.8$ when prices are the strategic variables, or $\delta \geq 0.25$ when quantities are the strategic variables.

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