# ENFORCEMENT OF COLLUSION IN OLIGOPOLY

by

David Levine

Working Paper #247
University of California, Los Angeles
Department of Economics
May 1982

*I am grateful to my advisors Peter Diamond, Timothy Kehoe and Franklin M. Fisher. I must also thank Drew Fudenberg, Judy Gelman, Jack Hirshleifer, Eric Maskin, John Riley, Richard Schmalensee and Peter Temin for helpful advice and comments.

## 1. Introduction

I wish to model a simple story about oligopoly. Suppose explicit negotiation and legally binding agreements are impossible. Cournot type capacity setting firms will not achieve the joint profit maximum for lack of ability to punish free-riders. Free riders can, however, be punished through the market: a firm which increases capacity in an attempt to garner a larger market share can be punished if the rest of the industry responds by increasing its capacity. Furthermore, each individual firm will find it in its own self-interest to develop a reputation for punishing free riders, since by doing so it forces down industry capacity and raises its own profits. Thus we should expect collusion to occur, even though firms behave non-cooperatively.

There is an additional aspect of the problem. It cannot generally be expected that enforcing collusive levels of capacity is costless — it is expensive to punish free-riders. Previous work by Stigler [11] and Spence [10] has pointed out that it is expensive to observe whether or not a rival is free-riding. It is also expensive to fulfill commitments on occasions when rivals test to see if they will be honored. The more costly are retaliatory strategies, the less collusion can be expected. Firms must weigh the additional benefits to them of less industry capacity against the additional expense of enforcing that level of capacity.

I build a model that tells this story and which has two other properties. It tells only one story: the model has a unique equilibrium. This is in contrast to the supergame model of Green [2] which has a continuum of equilibria. Second, the equilibrium has reasonable computational properties. Firms are able to compute their optimal strategy by extrapolating the recent behavior of opponents, and not from a detailed knowledge of rivals technology and the solution concept.

I am able to achieve both these goals by introducing two essential elements. I allow firms to make binding short-run commitments. I do not give a model of why such commitments are possible: they may arise from imitative behavior as described by Kreps, et al [3], or it may simply be that there is a psychic cost to the "loss of face" felt from failing to live up to one's reputation.

The second essential element I introduce is to treat both a firm's reputation for retaliation and its capacity as capital variables subject to expensive adjustment. Because these variables are (optimally) changed slowly, their paths can be extrapolated accurately into the medium run, while with a positive discount rate firms don't care much about the long run. Thus the (approximate) perfect equilibrium I derive has plausible behavioral properties as well as telling the correct story.

In the next section I describe the model of the industry. In Section Three I describe the solution concept. Section Four poses and answers a number of comparative dynamic questions that recount the story of oligopoly I told above. The concluding section debunks some myths about oligopoly.

## 2. The Model

An industry has $N$ identical firms with no possibility of further entry. Each firm $i$ is described by two state variables: a capacity $x_i$ and a reputation for responding to growth in rivals capacity $R_i$. Firm $i$ also has two control variables: the rate of change of autonomous capacity $y_i$ and the rate of change of reputation $S_i$. This section has three parts. The first part gives the equations of motion for the state variables conditional on the controls. The second part describes the objective function of firms. The third part describes the decision problem faced by firms. The equilibrium concept is described in the next section.

Equations of Motion: There is a simple commitment technology which relates the reputation of firms to the rate at which their capacity grows. The growth of firm i's capacity $\dot{x}_i$ is given by its autonomous growth $y_i$ plus its reputed reaction rate $R_i$ times the autonomous growth of rival firms

$$\dot{x}_i = y_i + R_i \Sigma_{j \neq i} y_j. \tag{2.1}$$

Implicitly it is assumed that $R_i$ represents an actual commitment; that in the short run firms find it costly to deviate from their reputed response rate. In the long run firms may alter their reputation by

$$\dot{R}_i = S_i. \tag{2.2}$$

No explicit model is provided to describe how firms form their reputations. They might simply announce their response rates $R_i$ and feel an implicit obligation to honor these commitments for at least short periods of time. Alternatively firms might attempt to infer responses by observing each other's output over time. Implicit also in (2.1) is that firms can distinguish between autonomous and total output changes by rivals. This assumption is designed solely to simplify the mathematics. In an earlier version of this paper [9] I considered the possibility that firms could respond only to total output changes by rivals and showed that it made no qualitative different in the conclusions.

Firm Objectives: Firm income at a moment of time is given by

$$(2.3) \qquad I_i = \pi_i(x) - F_i(R_i) - C_i(y_i, S_i).$$

The gross profits $\pi_i$ are derived from the assumption that firms produce to capacity and that marginal variable cost is constant and demand linear. Letting $\eta$ be the slope of the demand curve and $D$ the difference between price at zero industry output and marginal variable cost then

$$(2.4) \qquad \pi_i = [D - \eta \Sigma_j x_j] x_i .$$

The term $C_i$ is the adjustment or investment cost which is quadratic

$$(2.5) \qquad C_i = (2b)^{-1}[c^{-1}y_i^2 + S_i^2]$$

where $b$ and $c$ are positive constants describing the magnitude of the cost. That it is expensive to increase (or decrease) capacity is plausible. Similarly reputation has the dimension of a capital variable and is costly to adjust rapidly. The notion is that if a firm tries to change its reputation everyone knows instantaneously that old commitments are no longer being honored and the firm loses its reputation altogether.

The term $F_i$ is the frictional cost of maintaining a reputation. If a firm wishes to convince its rivals that it will respond to changes in their capacity by a response rate $R_i$ it must maintain expensive inventories and engage in expensive short run output changes to respond to opponents who wish to "test" its commitment. The higher the absolute response rate the higher the frictional costs as given by

(2.6) $$F_i = bf(N-1)|R_i|.$$

Here f denotes the product of frictional costs times adjustment costs: b is the same parameter as in (2.5). It is also implicit that frictional costs are proportional to the number of rival firms: the more opponents there are to respond to, the more costly is the response.

Finally, firms are assumed to be present value maximizers. They face a common interest rate which, by measuring time in appropriate units, is normalized to equal one.

The Decision Problem: The objects of choice by firms are closed-loop strategies

(2.7) $$(y_i, S_i) = \sigma_i(x,R)$$

which are rules for choosing the controls as a function of the state. Given starting values for the state variables x and R and strategy selections for all firms $\sigma$ the equations of motion (2.1) and (2.2) can be integrated forward and substituted into the instantaneous income functions to yield income $I_i(t)$ as a function of time for each firm. Thus, beginning at x,R, when $\sigma$ is played, firm i's present value is

$$J_i(x,R,\sigma) = \int_0^\infty I_i(t)\exp(-t)dt. \tag{2.8}$$

Suppose that $\hat{J}_i$ is an estimate of the maximum of $J_i$ over $\sigma_i$ given the strategies $\sigma_j$ of other firms. To find its individual optimum firm i should equate its marginal cost of investing to its estimated rate of return on investment. For example, to set the control $y_i$ firm i should equate the marginal cost $b^{-1}c^{-1}y_i$ to the derivative of the time rate of change of present value (equals the rate of return on investment) with respect to $y_i$; to set

$$b^{-1}c^{-1}y_i = \Sigma_j \frac{\partial \hat{J}_i}{\partial x_j}\frac{\partial \dot{x}_j}{\partial y_i} + \frac{\partial \hat{J}_i}{\partial R_j}\frac{\partial \dot{R}_j}{\partial y_i}. \tag{2.9}$$

Using the equations of motion (2.1) and (2.2) this simplifies to

$$y_i = bc\left[\frac{\partial \hat{J}_i}{\partial x_i} + \Sigma_{j\neq i}\frac{\partial \hat{J}_i}{\partial x_j}R_j\right]. \tag{2.10}$$

Similarly $S_i$ is given by

$$S_i = b\frac{\partial \hat{J}_i}{\partial R_i}. \tag{2.11}$$

It is an immediate consequence of Bellman's principle that if $\sigma$ is derived from (2.10) and (2.11) and $\hat{J}_i = J_i$ then $\sigma$ is the <u>perfect Nash equilibrium</u> described by Selten [19]: every firm behaves optimally given rivals' strategies and knows that regardless of initial conditions its rivals will do likewise. Unfortunately it is difficult to even prove the existence of a perfect equilibrium in this model, let alone to analyze its qualitative properties. As an alternative, in the next section an approximate equilibrium which satisfies plausible informational assumptions is derived.

## 3. The Solution Concept

An approximate equilibrium are functions $\hat{J}_i$ such that if all firms follow the strategies $\sigma$ defined by (2.10) and (2.11) the actual present values $J_i$ are approximately equal to the $\hat{J}_i$ for all initial conditions. Our approximation will require the strong assumption that adjustment costs are large (that the parameter b in (2.5) is small). In another paper [5] I show that the approximate equilibrium has correspondingly strong properties: the strategies played by each firm lose no more than $\varepsilon$ relative to the full optimum where $\varepsilon$ is small provided b is small. The approximate equilibrium is also approximately the same as any $\varepsilon$-perfect equilibrium which satisfies certain regularity conditions (all sufficiently regular perfect equilibria are approximately the same as the approximate equilibrium, for example). This is important, because it means that the approximate equilibrium isn't too sensitive to the rather ad hoc procedure used to derive it. (Note that all these properties correctly allow for the fact that as adjustment costs grow large the optimal adjustment speed grows small.)

Unlike the $J_i$ which require a global knowledge of the game and rivals' behavior the $\hat{J}_i$ should actually be computable by firms from information available at the current initial conditions. One way firms might form expectations of future income needed to compute their present value is to extrapolate current income linearly into the future; to estimate

$$I_i(t) \approx I_i(0) + \dot{I}_i(0)t. \tag{3.1}$$

Estimated present value of profits is then

(3.2) $$J_i(x,R) \approx I_i(0) + \dot{I}_i(0).$$

The error in the approximation (3.2) can be bounded by $\ddot{I}_i$. Letting $Z = (x_1,\ldots,x_n,R_1,\ldots,R_N)$ be the vector of state variables we can write

(3.3) $$\ddot{I}_i = \sum_j \sum_k \left[\frac{d^2 I_i}{dZ_j dZ_k} \dot{Z}_j \dot{Z}_k + \frac{dI_i}{dZ_j} \frac{d\dot{Z}_j}{dZ_k} \dot{Z}_k\right].$$

From (2.10), (2.11) and the equations of motion (2.1) and (2.2) the rate of change of the state variables can be written as

(3.4) $$\dot{Z}_j = b\, h_j(Z).$$

In other words, if the cost of adjustment in (2.5) is large the rate of adjustment in (3.4) is small and the error in (3.2) from (3.3) is

(3.5) $$\ddot{I}_i = b^2 \sum_j \sum_k \left[\frac{d^2 I_i}{dZ_j dZ_k} h_j h_k + \frac{dI_i}{dZ_j} \frac{\partial h_j}{\partial Z_k} h_k\right]$$

and is also small.

The conclusion of this discussion is that linear extrapolation is a reasonable behavioral rule provided that firms are willing to accept errors of order $b^2$ (the square inverse adjustment cost). Hereafter this is assumed to be the case:

<u>APPROXIMATION ASSUMPTION</u>: Adjustment costs $(1/b)$ are sufficiently large that firms will accept errors of order $b^2$ in computing the optimum strategy.

We compute $\hat{J}_i$ from (3.2) by ignoring terms of order $b^2$. Write out (3.2) as

(3.6) $$J_i \approx \pi_i(x)$$

$$- F_i(R_i) \qquad (A)$$

$$- C_i(y_i, S_i) \qquad (B)$$

$$+ [\sum_j \frac{\partial \pi_i}{\partial x_j} \dot{x}_j - \frac{\partial F_i}{\partial R_i} \dot{R}_i] \qquad (C)$$

$$- [\sum_j \frac{\partial C_i}{\partial y_i} (\frac{\partial y_i}{\partial x_j} \dot{x}_j + \frac{\partial y_i}{\partial R_j} \dot{R}_j) + \frac{\partial C_i}{\partial S_i} (\frac{\partial S_i}{\partial x_j} \dot{x}_j + \frac{\partial S_i}{\partial R_j} \dot{R}_j)]. \qquad (D)$$

As we observed above ((2.10), (2.11) and (3.4)) the controls $y_j$ and $S_j$ and the rate of change of the state variables $\dot{x}_j$ and $\dot{R}_j$ (that is, the $\dot{Z}_k$) are small; they are of order b. Thus the expressions in lines (B), (C) and (D) are proportional to b, while line (A) is proportional to b by assumption from (2.6). Differentiating (3.6) therefore yields

(3.7) $$\frac{\partial J_i}{\partial x_j} \simeq \frac{\partial \pi_i}{\partial x_j} + b \text{ [other terms]}$$

$$\frac{\partial J_i}{\partial R_i} \simeq b \text{ [various terms]}.$$

Assuming that $\hat{J}_i$ and $J_i$ are approximately the same (3.7) and (3.8) should hold also for $\partial\hat{J}_i/\partial x_j$ and $\partial\hat{J}_i/\partial R_i$. This can be used in (2.10) and (2.11) to find approximately $y_j$ and $S_j$ and with the equations of notion (2.1) and (2.2) to find $\dot{x}_j$ and $\dot{R}_j$. Substituting these back into (3.6) we find

$$(3.8) \qquad J_i \tilde{=} \pi_i$$

$$-bf(N-1)|R_i| \qquad (A)$$

$$-(1/2)\ bc\ [\frac{\partial \pi_i}{\partial x_i} + \sum_{j \neq i} \frac{\partial \pi_i}{\partial x_j} R_j]^2 \qquad (B)$$

$$+ cb \sum_j \frac{\partial \pi_j}{\partial x_j} \{\frac{\partial \pi_j}{\partial x_j} + \sum_{k \neq j} \frac{\partial \pi_j}{\partial x_k} R_k$$

$$+ R_j \sum_{k \neq j} [\frac{\partial \pi_k}{\partial x_k} + \sum_{m \neq k} \frac{\partial \pi_k}{\partial x_m} R_m]\} \qquad (C)$$

$$+ b^2 \text{ [other terms]}. \qquad (E)$$

By assumption, the terms of order $b^2$ in (3.8) can be ignored and we simply define $\hat{J}_i$ to be (3.8) with line (E) omitted. This solution gives the approximate equilibrium in closed form. As mentioned above, this solution has strong properties, including approximate uniqueness and dominance, which are developed in another paper [5].

The solution (3.8) can now be differentiated and used in (2.10) and (2.11) to find the equilibrium closed loop strategies. These in turn are used in the equations of notion (2.1) and (2.2) to find the motion of the state variables. Recall that all firms are assumed identical, including in initial choices of reputation and capacity. This means, since (3.8) is symmetric, that the reputation and capacity of firms will always be equal. Let $r = R_i$ be the common reputation of all firms, and define

$$(3.9) \qquad q \equiv (\eta/D)Nx_i$$

where $x_i$ is the capacity of any firm. Note by (2.4) that when the industry is at the competitive level of capacity $q = 1$ so $q$ can be interpreted as industry capacity measured as a fraction of the competitive level. In terms of the variables $q$ and $r$ the notion of the state variables can be compactly expressed as

$$\dot{q} = b(\eta/D)Nc[1+r][\frac{\partial\pi_i}{\partial x_i} + (N-1)r\,\frac{\partial\pi_i}{\partial x_j}] \tag{3.10}$$

$$+ b^2[\text{other terms}]$$

$$\dot{r} = b^2(N-1)\{c[\frac{\partial\pi_i}{\partial x_i}(\frac{\partial\pi_i}{\partial x_i} + (N-1)r\,\frac{\partial\pi^i}{\partial x_j})$$

$$+ \frac{\partial\pi_i}{\partial x_j}\,(r\,\frac{\partial\pi_i}{\partial x_i} + (1 + (N-2)r)\,\frac{\partial\pi_i}{\partial x_j})]$$

$$- f\ \mathrm{sgn}(r)\}$$

where

$$\mathrm{sgn}(r) \equiv \begin{cases} +1 & r > 0 \\ 0 & r = 0 \\ -1 & r < 0\ . \end{cases} \tag{3.11}$$

Equation (3.10) characterizes the condition of the industry over time.

## 4. Comparative Dynamics

This section studies the equations of motion derived in the previous section. It has three parts. The first part considers some global aspects of the dynamics. Part two considers steady state behavior in the short run. In the short run the response rate $r$ is determined by initial conditions while industry output is at the "conjectural variational equilibrium" where firms conjecture that opponents will respond with the variation $r$. Part three analyzes the long run. In the long run $r$ is determined endogenously: it is this feature which distinguishes this theory from previous oligopoly theories. In the long run, steady state output lies between the monopoly and Cournot-Nash output depending on the exogenous parameters of the market. The most significant result is that when there are no frictional costs of response output is at the monopoly level independent of other market parameters. Several comparative dynamic exercises show how long-run output varies with market parameters when frictional costs are positive. Several proofs have been omitted for brevity and can be found in an earlier version of this paper [4].

Global Aspects: An overall qualitative aspect of the system (3.10) is that for almost all initial conditions $q$ and $r$ eventually reach the region $0 < r$ and $0 < q < 1$. For example, all stable steady states are in this region. This makes good economic sense. If $q > 1$ firms make negative profits and should reduce output. If $r < 0$ each firm is rewarding its opponents for hurting it and penalizing them for helping it. Hereafter we restrict attention to the case $0 < q < 1$ and $r > 0$.

The Short Run: Inspection of the equations of motion (3-10) shows that $q$ adjusts at a speed proportional to $b$ while $\dot{r}$ is proportional to $b^2$.

Since $b$ is assumed small this means $q$ adjusts much more quickly than $r$. In the short run $q$ moves rapidly towards the curve $\dot{q} = 0$, while $r$ is close to its starting value. Examination of (2-12) shows that $\dot{q} = 0$ implies

$$(4.1) \qquad \frac{\partial \pi_i}{\partial x_i} + (N-1)r \frac{\partial \pi_i}{\partial x_j} = b \text{ [various terms] } \simeq 0$$

If the right hand side vanished this would be exactly the first order condition for choosing the optimal output level subject to the conjecture that opponents of $j$ respond to output changes $\Delta x^j$ by $r\Delta x^j$. Thus, in the short run, the steady state resembles the traditional conjectural variational equilibrium, as described for example by Seade [8].

From (4-1) and (2-4) the curve $\dot{q} = 0$ is seen to be

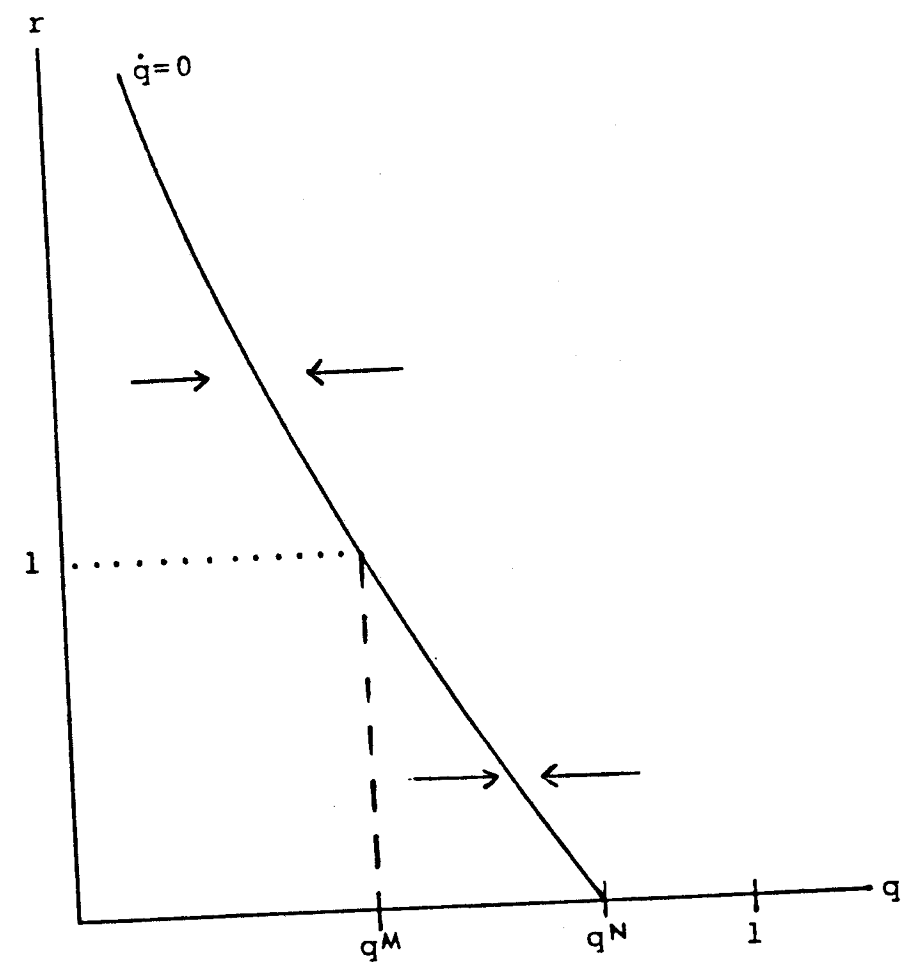
$$(4.2) \qquad r \simeq \frac{N-(1+N)q}{(N-1)q}$$

which is sketched in Figure (4-1). The curve strictly decreases. This reflects the fact that the more $j$'s opponents reward him for cutting output by responding with output cuts of their own (as reflected in large $r$) the lower $j$ will choose to set his output.

At the monopoly output $q^M \equiv (1/2)$ the reaction $r = 1$ while at the Cournot-Nash output $q^N = N/(1+N)$ the reaction $r = 0$. Finally, a computation shows that for $\partial\dot{q}/\partial q < 0$. Thus in the short run $q$ moves towards the curve $\dot{q} = 0$, and the short-run steady states are globally stable.

<u>The Long Run</u>: The theory of oligopoly developed in the previous sections differs from orthodox theory because in the long run $r$ is determined endogenously. In addition to satisfying $\dot{q} = 0$, in the long run steady state

FIGURE (4-1): THE SHORT RUN STEADY STATE CURVE



$\dot{r} = 0$ must be satisfied. Using (4-2), and (3-10) to solve these conditions we find the long-run steady state output

(4.3) $$q^S = \frac{3}{4} - \sqrt{\frac{1}{16} - \Psi}$$

$$q^U = \frac{3}{4} + \sqrt{\frac{1}{16} - \Psi}$$

where the constant

(4.4) $$\Psi \equiv \frac{(N-1)f}{2D^2c} > 0$$

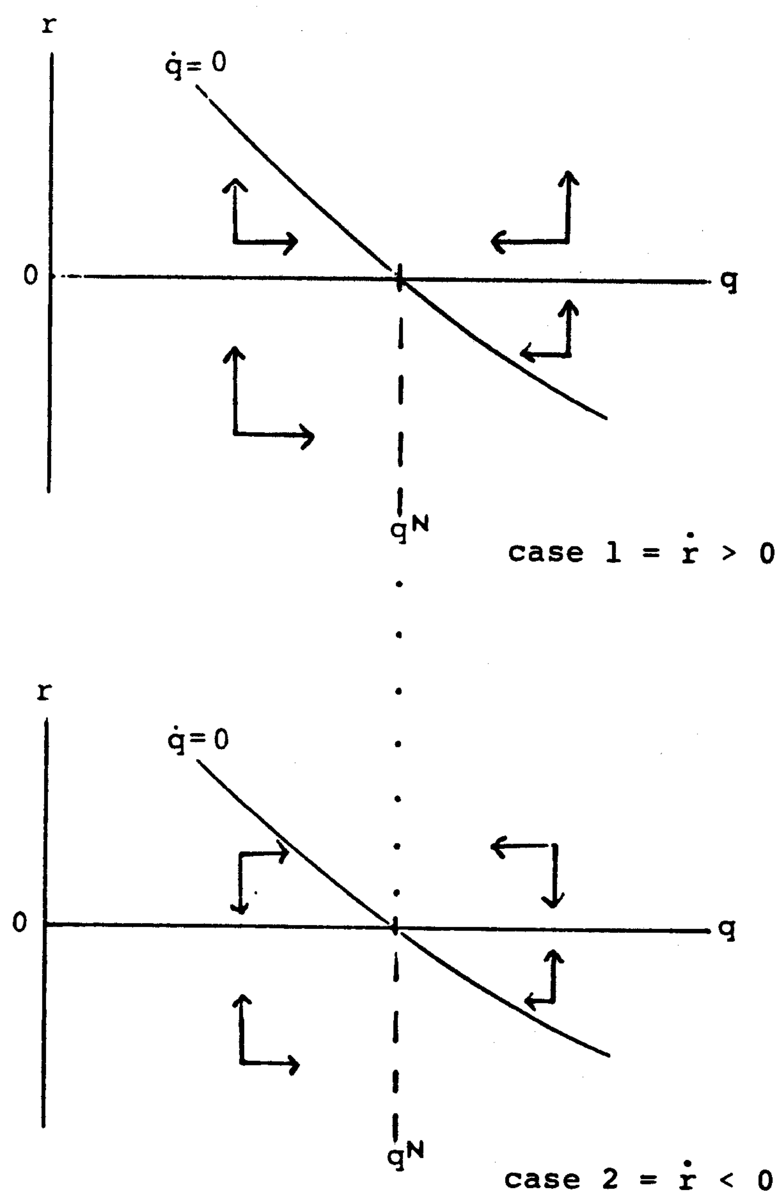
Since $r > 0$ by (4-2) these steady states exist only when the corresponding output is no greater than $q^N$. In addition neither steady state exists if $\Psi > (1/16)$. It can be shown by direct computation that the steady state at $q^S$ is stable and the steady state at $q^U$ unstable. (For a minor exception see [4].)

There is one other possibility. Since $\dot{r}$ is discontinuous along $r = 0$ there can be a steady state at $r = 0$ and $q = q^N$. From Figure (4-2) this occurs exactly when $\dot{r} < 0$ for $r$ small and positive, in which case the steady state is stable. A computation shows that the relevant condition for $\dot{r} < 0$ is $\Psi > \Psi^N \equiv (N-1)/2(1+N)^2$.

The next stage of analysis is to determine how the location of steady states depends on $\Psi$ for N fixed. There are two cases in analyzing steady state output $N = 2,3$ and $N > 4$. The economic significance of the cutoff value $N = 4$ is doubtful — it is probably an artifact of the functional form.

When $N = 2,3$ we see from (4-3) that there is a unique steady state with $r > 0$, it is stable, and it increases in M. For $0 < \Psi < \Psi^N$ the steady

FIGURE (4-2): THE PHASE PORTRAIT NEAR $q^N$



state output is given by $q^S$. For $\Psi > \Psi^N$ steady state output is at the Cournot-Nash level. This situation is illustrated in Figure (4-3).

When $N \geq 4$ the situation is more complex. Define the cutoff point $\Psi^B = (1/16)$. When $\Psi = 0$ there is a unique steady state (which is stable) at $q^S = q^M$ and $r = 1$. As $\Psi$ increases to $\Psi^N$ there is still a unique steady state (stable) with output $q^S$. For $\Psi^N < \Psi < \Psi^B$ there are three steady states with output $q^S$ (stable), $q^U$ (unstable) and $q^N$ (stable). When $\Psi > \Psi^B$, $q^S$ and $q^U$ meet at $(3/4) = (q^M+1)/2$ and vanish leaving just one steady state (stable) at $q^N$. Figure (4-4) diagrams steady state output. As in the case $N = 2,3$ output increases in $\Psi$. However a discontinuity in steady state output can occur when $\Psi = \Psi^N$ or $\Psi = \Psi^B$ as the system jumps from one steady state to another.

From (4-4) $\Psi$ and thus industry output as a fraction of the competitive level increases in N and f and decreases in D and c. That increases in N lead to more competition shouldn't be too surprising. In this model f represents the marginal cost of enforcing a collusive arrangement — of increasing $R_i$. Thus when f is large there is less collusion. There is also a public goods problem in allocating enforcement costs among firms. When N is large each firm has less incentive to bear its share of the burden and long-run output is greater. The fact that competitiveness declines in D is perhaps a bit surprising. This happens for two reasons. First, f/D, which is the cost of enforcing collusion divided by a variable describing the marginal profitability of increasing output, declines. Thus D serves to scale f: it isn't enforcement costs, but the ratio of marginal enforcement costs of marginal market profitability that matters. Second, from the equation of motion for q (3-10), when D increases, firms adjust output more quickly due to the increased marginal profits from doing so. Increasing

FIGURE (4-3): THE CASE N = 2,3

Arrows Denote Movement in $q^S$ for N Fixed as M Increases

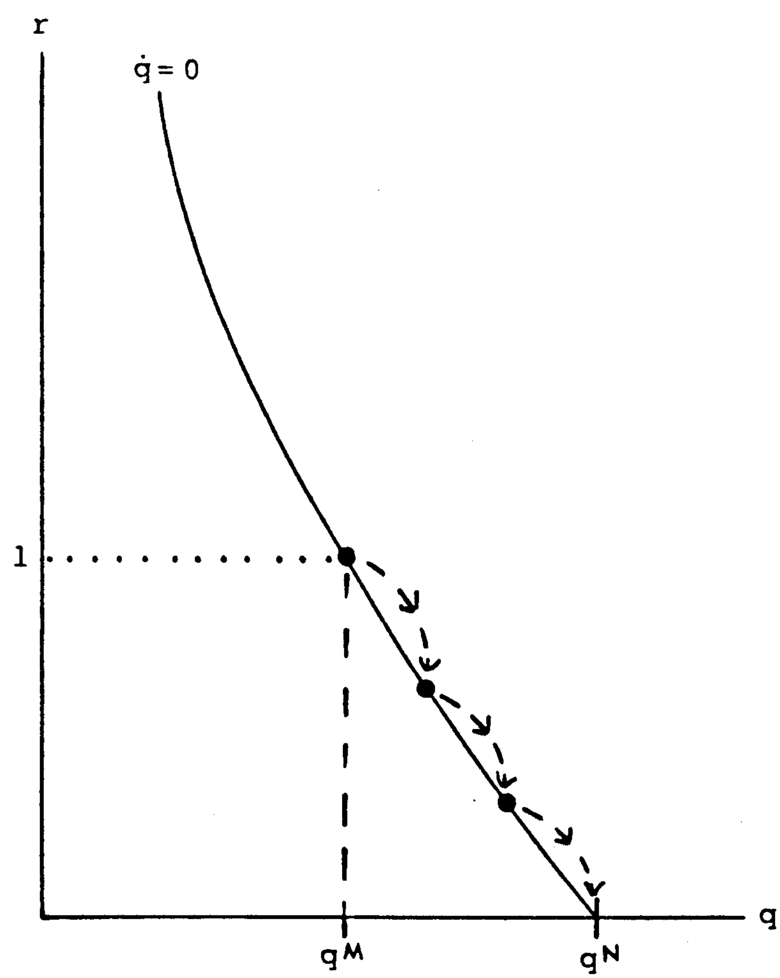
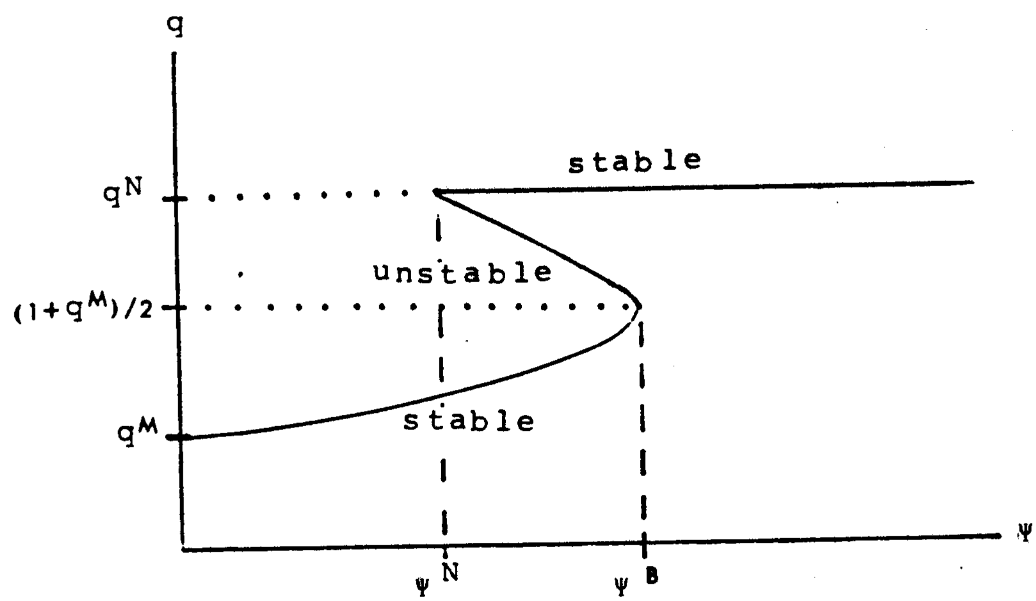


**FIGURE (4-4): STEADY STATE INDUSTRY OUTPUT**

**$N \geq 4$ and held fixed**



c also increases the speed with which firms adjust. Why does more rapid adjustment of output enhance collusion? The benefit of setting high values of $R_i$ and thus realizing relatively collusive arrangements lies in the effect this has on opponents' future output. The more quickly they adjust, the more quickly these benefits are realized and with discounting fixed, the more valuable they are. Thus raising D, or c both have the effect of reducing competitiveness.

## 5. Facts and Myths about Oligopoly

The results of this paper contradict a number of widely believed myths about oligopoly. To conclude the paper I debunk several of these myths.

Infinite Response is Optimal: It is frequently argued that by making sufficiently large threats against opponents a firm can get them to do anything it wants. Thus (when there are no frictional costs of response) an infinite response is optimal. In the context of this paper the argument is false — the long-run steady state reaction coefficient was computed equal to one. It is true that each firm controls the output of all its rivals when they follow the equilibrium adjustment procedure. The objective, however, is profit and not control of opponents output. A firm can drive opponents' output to zero, and perhaps even increase its market share while doing so, but to do so it must cut its own output so much it loses profits.

Only if one firm can permanently commit itself to a policy of predatory threats and instantly communicate this to rivals, can it successfully dominate the market.

Negative Response is Optimal: The assertion is that when an opponent increases output it is optimal to reduce output. This is true, for example, in the static model of Bresnahan [1]. In this paper, however, the converse is true — all stable steady states have non-negative response rates. Why is this?

Lowering output in response to an opponent's increase has two effects: it increases profits, and it encourages the rival firm to increase output even further. At a steady state only the latter effect matters — rival firms aren't going to change output unless encouraged to do so. The fact is that retaliation affects the behavior of opponents. Only when it does not should opponents output increases be met with reductions.

Negotiation Matters: The institutional industrial organizational literature, for example Scherer [7], frequently distinguishes between explicit collusion where firms negotiate output shares and implicit collusion where they do not. It argues that in the former case firms will always collude fully because it is "jointly optimal" to do so. Does explicit collusion invalidate the results of this paper?

The key question is: how is collusion enforced? Even if an agreement is reached what keeps firms from cheating on it? The answer is: precisely the mechanism described in this paper.

It is a mistake to think that talk alone will cure the problem of enforcing collusive arrangements.

Facts about Oligopoly: This paper has examined how firms (almost) rationally choose short run commitments to retaliatory strategies. The result is a simple sensible story of oligopoly: firms punish uncooperative opponents and reward cooperative ones. In the long-run steady state this implies that market competitiveness depends on the frictional costs of enforcing collusive arrangements.

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