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ASYMMETRIC OLIGOPOLIES

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Abstract: Interest has been focused on the problem of enforcing compliance in collusive oligopolies by the suggestion that shifts in these incentive compatiblity constraints could explain the cyclical behaviour of inventories and of price-cost margins. This paper notes cross sectional implications of incentive compatibility constraints in asymmetric collusive oligopolies which may be useful in evaluating the prevalence of collusion or binding incentive compatibility constraints.

I would like to thank Stephen Martin, Hans Peter Møllgaard, Louis Phlips and Michael Woodford for useful discussions

INTRODUCTION

Supergame theoretic models of collusive oligopolies have been proposed to explain important properties of the business cycle - procyclical inventories and countercyclical markups (Rotemberg and Saloner 1985, Rotemberg and Saloner 1986, Rotemberg and Saloner 1989, Rotemberg and Woodford 1989). Such results may even help explain the business cycle. The predictions of the theories on the cyclical behavior of inventories and markups are being tested. Unfortunately the tests cannot go far beyond documentation of the stylized facts to be explained in the first place. Furthermore, like all statistical tests they depend on auxiliary assumptions. It is clearly desirable to identify and test other implications of the theory.

The Nash supergame theoretic models of collusive oligopoly can also be tested because they make strong predictions about the behavior of firms of different sizes. Largely for reasons of tractability, existing models consider symmetric duopolies. While confining attention to duopolies, it is possible to discuss interesting applications of the theory for the behavior of duopolies consisting of one firm with a high capacity and one firm with a low capacity. I suggest that the implications are simple, the big firm does more than its share of the work of preventing competition and the little firm gets a relatively free ride at the expense of the big firm as well as of the consumer.

This has various implications given the various means that collusive oligopolists are alleged to enforce collusion. For different models the large firm will hold greater excess capacity, store large inventories and charge a slightly higher price for an identical good.

An extreme case illustrates this claim. Here as in the actual model I will assume that marginal cost is constant up to maximum capacity at which point it becomes infinite. In particular consider a collusive quantity setting duopoly which consists of a firm with very large capacity K and a firm with tiny capacity epsilon (ε). As is standard I assume that firms agree on quantities to produce, then decide how much to actually produce, taking the other firms (correctly) expected output as given. Any retaliatory action takes place in later periods.

So long as total output is at least as great as the output which maximizes profits (which would be ridiculous) the large firm will gain little by increasing output even if the small firm has no ability to punish it. The reason is clear, Total profits will fall and the small firms profits are εp to begin with so they can't fall much. This leaves virtually nothing to tempt even the most unscrupulous manager of the large firm. In other words, the large firm is virtually a monopolist to begin with so it needs little incentive to refrain from increasing output.

Slightly more formally, The large firm will certainly not produce more than a monopolist facing the same demand curve would. This means that it will increase output by no more than the agreed output of the small firm which is itself less than or equal to ε. The increased profit obtained by increasing output to the static profit maximum is second order in the increase in output ε.

In contrast, in the single period game, the small firm is almost competitive. Even if it produces to capacity it will have only a small effect on prices. Therefore its profits will increase first order in the increase in output. This increase must be small since the firms total capacity is small and so is its unused capacity. It is at least reasonable to suppose, as will be demonstrated more formally below the small firm will gain greater dollar profits from defecting unless it is producing at or very near capacity already. Otherwise its gains from defection will be greater in absolute (not just greater in proportion to its profits if it does not defect).

Abandoning all efforts to sneak a model into the introduction, I will only note that It is not easy for the large firm to impose large costs on the small firm which has small profits even when unpunished. In contrast even with a small ability to drive down prices, the small firm can impose appreciable costs on the large firm whose large output makes the dollar cost of a small drop in prices large. The implication of this argument is that the small firm will use almost all of its capacity even when cooperating.

The conclusion that the incentive compatibility constraint on the small firm is more difficult to satisfy has many interesting and testable implications. As argued above, large firms in collusive oligopolies in Nash equilibrium will leave a larger fraction of their capacity unused.

Similar logic implies that large firms will hold larger strategic inventories proportional to output. Since strategic inventories are difficult to distinguish from other inventories, this prediction can only be used to see if Nash-rational strategic inventories are a significant component of inventories.

More interestingly, if the incentive compatibility constraint is binding on the small firm(s) in an oligopoly, but not on the large firm(s), the large firm(s) will attempt to guarantee the sales of the small firms. This is difficult if firms can not anticipate demand perfectly and quite difficult if the large firm does not have access to all the information which is available to the small firm(s). One simple solution is for the large firm(s) to charge slightly more than the small firm(s) and ration consumers. This would imply price differentials even if the products of different firms are perfect substitutes. This prediction is very striking but not a firm implication of the model, since such behavior is especially likely to alert any regulators who are willing to pay attention.

This article is divided into seven sections the first of which is this introduction. The second discusses earlier work along similar lines. The third presents and develops a model of an asymmetric collusive duopoly producing a non-storable good with constant demand. The fourth discusses a durable good which is inventoried for strategic purposes and reports that larger firms will hold proportionally larger inventories. The fifth introduces uncertain demand and reports results on the benefit for the large firm of smoothing demand for the output of the smaller firm and therefore of charging a slightly higher price and letting the small firm ration consumers. The sixth discusses extensions of the results. The Seventh concludes and discusses proposed empirical tests of the predictions of the model.

II PREVIOUS WORK

In recent years economists have suggested that two long-standing empirical puzzles can be understood if covert perhaps implicit cartels are common and important.

The first puzzle is the apparent counter-cyclicality of the ratio of price to marginal cost. Estimates of this ratio for aggregate manufacturing are counter-cyclical (Bils 1987). It is particularly suggestive that estimates of the markup are more counter-cyclical for concentrated industries than unconcentrated industries (Dommowitz, Hubbard and Petersen 1988). Furthermore it is necessary for markups to be counter-cyclical for a demand based explanation of the business cycle to be consistent with the observed pro-cyclicality of real wages (Bils 1985, Barsky and Solon 1985).

There are proposed explanations of counter-cyclical markups which do not refer to cartels (Dommowitz, Hubbard and Petersen 1986, Bils 1989). Nonetheless an explanation which has received intense attention depends on the suggestion that cartels find it more difficult to enforce compliance when the level of demand is high than when it is low (Rotemberg and Saloner 1986, Rotemberg and Woodford 1989).

The second puzzle is the positive correlation of inventories and sales or in other words the greater variance of output than of sales. There are many proposed explanations of this pattern. One explanation is that colluding firms hold strategic inventories and threaten to sell them in order to punish deviation from the collusive agreement. Again it is assumed that it is more difficult to enforce collusion when demand is high than when it is low (Rotemberg and Saloner 1985, Rotemberg and Saloner 1989).

The possibility that models of cartels can explain patterns which are otherwise mysterious has caused a sharp increase of interest by non-specialist economists in models of cartels. This in turn makes it more important to derive testable predictions about the behavior of cartels. In particular the models discussed above rely on the assumption that cartel behavior is determined by binding incentive compatibility constraints. This means that it is important to derive testable predictions about the behavior of cartels with binding incentive compatibility constraints. Earlier interest motivated by the effort to implement antitrust legislation did not focus on this question.

In this paper I propose that binding incentive compatibility constraints have clear implications for the behavior of asymmetric collusive duopolies. There has been relatively little work on asymmetric cartels, perhaps because theorists are not confident about how to solve cooperative games without appealing to symmetry. It is necessary to decide whether the results are sensitive to the particular bargaining solution used. Schmalensee analyses a model in which different members of a Cartel have different marginal costs which are constant for each firm (Schmalensee 1987). Osborne and Pitchik analyze a model still closer to the model which is the main focus of this paper. They assume that all firms have the same constant marginal cost but have different capacities (Osborne and Pitchik 1983). Neither article focusses the incentive compatibility constraint or asymmetries in the incentive compatibility constraint.

A separate literature on cartel stability considers incentives and asymmetric cartels (Donsimoni 1985, Donsimoni, Economides and Polimarchakis 1986,Martin 1990) literature is quite different from that which Rotemberg and Saloner and Rotemberg and Woodford use and extend. It addresses the same question but gives very different answers for two reasons: defection is assumed to be observable immediately and the game is assumed to be one shot (or finitely repeated) so punishment strategies are dynamically inconsistent. This implies that the conclusions concerning incentive compatibility are completely different and while they cast doubt on theories which appeal to collusion in explaining macroeconomic phenomenon they do not help one to draw testable predictions based on such theories.

In marked contrast to the relative absence of theoretical work, case studies of confessed cartels discuss asymmetries in the behavior of the member with the lowest cost (or largest capacity). The qualitative behavior of the members of the oligopoly is as proposed in this article: the largest producer bears a more than proportional share of the costs of enforcing collusion. It holds more than proportional excess capacity and serves as a swing producer absorbing more than its share of fluctuations in demand. In the most prominent case, OPEC, this pattern is familiar to everyone who reads newspapers (even me). It is also observed for "most" of ten other successful cartels (Eckbo 1976). To my knowledge empirical researchers have not developed theoretical models which might be used to determine whether the observation reflects peculiarities of the cases studied rather than a general rule which might be expected to apply to covert cartels.

The theoretical and empirical literatures do not correspond closely. Most theoretical papers consider symmetric cartels as do all theoretical applications of cartel theory to problems in macroeconomics. In contrast case studies of known cartels emphasize the importance of asymmetry. An analysis of the implications of asymmetry for cartel behavior might bring the two strands closer together.

III A SIMPLE MODEL

Consider two rational profit maximizing firms facing a linear inverse demand curve with fixed marginal cost up to a fixed maximum capacity. The inverse demand curve is given by equation 1

1) $p = a - b(q_1+q_2)$

where p is price and q_i is the quantity produced by firm i. For firm i marginal cost is equal to m a constant up to exogenous maximum capacity K_i, where $K_1 < K_2$. The game is repeated indefinitely but the good is not storable. The firms agree on planned outputs s_1 and s_2 at the beginning of each period t (time subscripts are suppressed on the promises for notational simplicity). Then they chose how much to actually produce given their (assumed to be correct) beliefs about the level of output being chosen by the other firm and the consequences of breaking their promises. After suitable apologies to Dilip Abreu (Abreu 1986, Fudenberg and Maskin 1986) assume that if any firm breaks its promise firms simply cease to collude and produce the static Cournot Nash equilibrium outputs (Friedman 1971,1983).

In period two, Firm i chooses q_i to maximizes the discounted stream of profits

2) $$Vi = \sum_{t=to}^{\infty} (1/(1+r))^{(t-t_o)}(a-b(q_{1t}+q_{2t})-m)q_{it}$$

where r is the rate of discount and q_{it} is the quantity produced by firm i in period t. q_{it} clearly depends on whether any firm has cheated before time t.

since the problem is stationary $s_{it} = s_i$ the same for every t, and, since there is no uncertainty, no promises are broken in Nash equilibrium. So in equilibrium firm i receives profits of present value

3) $V_i = ((1+r)/r)(a-b(s_1+ s_2)-m)s_i$

where s_1 and s_2 are determined by bargaining.

Each firm faces the temptation to choose the static profit maximizing level of output and then (by assumption) the Cournot Nash level of output and profits in all future periods. To determine the incentive compatibility constraint it is necessary to calculate the static profit maximizing level of output given the planned output of the other firm and to calculate the static Cournot-nash equilibrium. Firms i's profits under the Nash assumption that firm j firm keeps its promise is given by 4

4) $profit_{it} = (a-b(s_j+q_i)-m)q_i$

This gives profit maximizing output

5) $q_{it} = (a - bs_j -m)/2b$

which firm i will produce if it has the capacity. This is greater than output in the static Cournot-Nash equilibrium and for simplicity is assumed to be greater than K_i. So the firms are assumed to produce to capacity if they defect and obtain profit

6) $profit_{it} = (a - b(s_j+K_i) - m)K_i = (a - b(s_j+s_i) - b(K_i-s_i) - m)K_i$

Unfortunately for the dishonest firm, it must settle for Cournot-Nash profits in subsequent periods. For simplicity assume that firms find it profitable to produce at full capacity in Nash equilibrium (and would produce more if they had the capacity). This has the added advantage of making it impossible for firms to punish each other more severely than by moving to the static Cournot-Nash equilibrium so I don't have to apologize to Abreu. There is little reason for a firm to produce capacity that it won't use even in the static Nash equilibrium (of course this argument should follow from a serious discussion of capacity choice). If so, the present value of the stream of profits of a defecting firm is given by 7

7) $V_i = (1/r)(a - b(K_1+K_2) - m)K_i + profit_{it}$

which finally gives the incentive compatibility constraint for firm i

8) $s_i \geq K_i\{(a - b(s_j+s_i) - b(K_i-s_i) - m) + (a - b(K_1+K_2) - m)/r\}/\{[a-b(s_1+s_2)-m](1+r)/r\}$

which holds so long as it uses its full capacity when it defects and both firms use full capacity in Cournot-Nash equilibrium.

Equation 8 implies that if firm 1 has smaller capacity than firm 2 the incentive compatibility constraint binds when its output is a larger fraction of that capacity. The minimum incentive compatible value of s_1/K_1 differs from the minimum s_2/K_2 only because of the term $-b(K_1-s_1)$ in the numerator. This is the amount of unused capacity, not the fraction of capacity unused, so if $s_1/K_1 = s_2/K_2$ the incentive compatibility constraint on s_1 binds if the incentive compatibility constraint on s_2 binds.

Comparison of the minimum s_i given by the incentive compatibility constraint with the output which would be given by an enforceable cooperative solution is made simpler by restating the benefits and costs of defecting in terms of differences from the static Cournot- Nash equilibrium profits. A firm defects if the difference between its profits if it defects and its profits if it cooperates is greater than the present value of the difference between its profits in the cooperative solution and in the static Cournot-Nash equilibrium. That is if 9 holds

9) $PD_i - PC_i <= (PC_i - PNC_i)(1+r)/r$

where PD_i is the maximum profit firm i can obtain if it defects from the cooperative solution, PC_i is the profits it obtains each period under the cooperative solution and PNC_i is the profits it obtains each period in the static Cournot-Nash equilibrium. PD_i-PC_i can be calculated for the simple linear inverse demand function from the first derivative of profits with respect to q_i at $q_i = s_i$ which is given by 10.

10) $dProfit_i/dq_i = (a - b(2s_i+s_j) - m)$

Note that the derivative is larger for firm 1 than firm 2 if s_1 is less than s_2. The second derivative of profits with respect to q_i is simply -2b for the linear inverse demand function. Even for more general inverse demand functions it is the same for both firms. This means that if neither firm produces at capacity when defecting, $PD_1 - PC_1$ is greater than $PD_2 - PC_2$ if s_1 is less than s_2.

Even if firm 1 produces at capacity when it defects, it gains more from defecting than firm 2 if s_1 is sufficiently smaller than s_2 so that 11 holds

11) $(a - b(2s_1+s_2) - m)(K_1-s_1) - (K_1-s_1)^2b >$
$(a - b(2s_2+s_1) - m)(K_2- s_2) - (K_2- s_2)^2b$

This condition will hold in any cooperative equilibrium. The reason is that there is no reason for a collusive oligopoly to produce less than a monopolist. They might produce more in order to reduce the temptation to defect but certainly won't produce less. This means that an increase in output reduces total profits or in other "words"

12) $(a-b(2s_1+2s_2)-m) < 0$

This means that if s_1 is less than s_2 and if inequality 13 holds then inequality 11 holds and the gain to firm 1 from defecting is definitely greater than the gain to firm 2.

13) $s_2(K_1-s_1) - (K_1-s_1)^2 > s_1(K_2- s_2) - (K_2- s_2)^2$

If s_i were proportional to K_i the smaller firm would gain more form defecting than the large firm since the first terms in the sums would be equal and the second term would be further below zero for the large firm. In contrast, the difference between profits under the cooperative and Cournot-Nash equilibria would be greater for the large firm, since such costs are proportional to capacity. This means that only the incentive compatibility constraint of the small firm could bind. This virtually rules out output proportional to capacity unless neither constraint binds in equilibrium (in which case supergame theoretic models have no interesting implications).

Except for the amazing coincidence of the constraint just binding when the firms share the monopolists output proportionally, binding incentive constraints imply that the larger firms uses a smaller fraction of its capacity in equilibrium. If incentive compatibility constraints affect the equilibrium at all they will cause the large firm to use a smaller share of its capacity in equilibrium.

This argument is quite general and does not depend on the linearity of the inverse demand function. For a more general inverse demand function b would be replaced by different constants for the collusive price and the derivative of the inverse demand function at the collusive output to obtain the derivative of profit with respect to output at s_i. In the squared terms 2b would be replaced by the second derivative at some point between s_i and K_i to apply the mean value theorem and calculate the gain from deviating. The inequality would still hold.

The argument remains valid if marginal costs are increasing on the reasonable assumption that marginal cost depends on the fraction of capacity in use. In general if the large firm maximizes profits by increasing production by x% when it defects, the smaller firm can obtain a larger benefit from defecting if it increases production by x% and still higher profits if it increases production by the optimal amount.

This implies that if any incentive compatibility constraints are binding the large firm must use a smaller fraction of its capacity than the small firm. Unfortunately this prediction is difficult to test, since it is difficult to measure capacity.

It does suggest that the return on capital should be smaller for the large firm than for the small firm. This prediction is not firm, since it is possible that large firms benefit from efficiencies of scale.

Beyond description of the incentive compatibility constraints, analysis of the incentive compatible cooperative equilibrium requires discussion of cooperative theories and bargaining. The remainder of the paper largely discusses the question of which incentive compatibility constraints bind at the cooperative equilibrium which would be achieved if bargains could be legally enforced. I conclude that, under any reasonable assumptions, the constraint on the small firm is tighter -- that it certainly binds if the constraint on the large firm binds.

In any collusive equilibrium each firm must produce enough to satisfy 9 and 10. To say more one must turn to cooperative game theory e.g. the Nash bargaining solution in which the oligopoly agrees to maximize

14) $(PC_1 - PNC_1)^x(PC_2 - PNC_2)$

where PC_i is the present value of profits received by firm i under the agreement, PNC_i is the profits achieved by firm i without agreement and x is a weight reflecting bargaining strength. The firms will maximize 14 subject to the incentive compatibility constraints described by equations 9 and 10. PNC_i is simply $(a - b(K_1+K_2) - m)K_i(1+r)/r$. x is more problematic. Equal weight, that is x = 1, is suggested by the original logic of Nash's argument and, still more, the non- cooperative interpretation of the solution provided by Rubenstein (1982). On the other hand intuition (and English) suggests that a large firm will have greater weight than a small firm and x will equal say K_1/K_2. I will confuse the following discussion by checking which results hold under both assumptions.

I will start with the assumption that $x = K_1/K_2$. It is clear that at the maximum of 14 (which may not be incentive compatible) each firm will produce output proportional to its capacity. This implies that if either incentive compatibility constraint constrains the bargain, it is the constraint on the capacity of the smaller firm.

Since firms can transfer profits by increasing the scheduled produciton of one firm and decreasing the scheduled production of the other, equal weight implies that the firms benefit equally from the collusive agreement. The effect of collusion is twofold -- the firms obtain a higher price and they produce less output. Let the collusive price be $price_c$ and the Cournot-Nash price be $price_n$. Then 15 describes the gains from colluding

15) $PC_i - PNC_i = (price_c - price_n)(K_i) - (price_c - m)(K_i - s_i) = PC_j - PNC_j$

This implies that in the cooperative equilibrium the difference in unused capacity is a fraction of the difference in capacity as described by equation 16

16) $(K_1-s_1) - (K_2- s_2) = [K_1-K_2](price_c-price_n)/(price_c - m)$.

Which is equivalent to equation 17

17) $(K_1-s_1) - (K_2- s_2) = [K_1-K_2]b(K_1- s_1 + K_2- s_2)/(price_c - m)$.

Equation 17 implies that the excess capacity of the smaller firm is less than the excess capacity of the larger firm (which is to say the least unsurprising). Equations 16 and 17 are implied by equal sharing of the gains from oligopoly. If a firm has an incentive to cheat when the oligopoly splits the gains evenly, the firms may agree to a lower price. The other firm may give the potential cheater a larger share of the profits or may agree to a higher output level but in any case will not give up more than it has to. This means that if an incentive compatibility constraint binds when gains are shared equally, it will bind with equality in the incentive compatible equilibrium. Equation 17 will be used without further apology.

Since each firm is assumed to benefit equally from collusion, each is punished equally severely for defection. The only difference between the two incentive compatibility constraints is the difference between the profits obtained by defection. Subtracting the second term of inequality 11 from the first gives equation 18 which describes the difference between the gain from defection for firms 1 and 2.

18) $dif = gain1 - gain2 = (price_c - m - bs_1)(K_1 - s_1) - (price_c - m - b s_2)(K_2 - s_2)$
$- (K_1-s_1)^2b + (K_2- s_2)^2b$

A little algebraic manipulation gives

19) $dif = \{price_c - m - b(s_1 + s_2)\}(K_1 - s_1 -(K_2 - s_2)) +$

$bK_2(K_1 - s_1) - bK_1(k2 - s_2) - (K_1-s_1+K_2- s_2)(K_1 - s_1 -(K_2 - s_2))b$

and

20) $dif = (price_c - m - b(s_1 + s_2)(K_1 - s_1 -(K_2 - s_2)) +$

$(K_2 - K_1)(K_1 - s_1 + K_2 - s_2)b/2 + (s_1 + s_2)[K_1 - s_1 -(K_2 - s_2)]b/2 -$

$(K_1 - s_1 + K_2 - s_2)[K_1 - s_1 -(K_2 - s_2)]b/2$

plugging equation 17 into equation 20 gives equation 21

$$21)\ dif = [K_1 - s_1 - (K_2 - s_2)]\{price_c - m - b(K_1 + K_2)\}/2$$

The term in square brackets, the difference in excess capacities is clearly negative as noted above. The term in braces is strictly less than the effect of an output on joint profits at the collusive equilibrium and must be negative. This means that the smaller firm is closer to its incentive compatibility constraint. If the constraint is violated at the joint profit maximum, the firms will have to settle for a lower price. This means that the large firm will be able to bargain for a division of profits in which the constraint of the small firm is binding and its own constraint is not. This situation has many interesting implications which will be explored in the next section.

First it is necessary to decide if the large firm finds this optimal or if it would prefer to accept less than half of the benefits of oligopoly in order to achieve a higher price. As noted above, the small firms incentive compatibility constraint can be satisfied by increasing both firms output and accepting a lower price or by keeping the price the same and giving it a larger share of the sales. It is clear that the large firm will not choose an outcome in which it gets less than half of the benefits form oligopoly. Consider small changes from the outcome in which gains are shared equally and the first firms constraint is binding. An increase in the price increases the small firm's incentive to defect, so the large firm would have to bear more than all of the costs of increasing the price. This clearly reduces its profits. This means that the large firm will choose an outcome in which the incentive compatibility constraint of the small firm is just binding and its own constraint is not binding.

The results with equal bargaining weights were derived for extremely simple and unrealistic assumptions about technology and demand. It is not clear (at least to me) if they generalize. Combined with the clear and general results for bargaining weights proportional to capacity they give a very strong presumption that in actual collusive duopolies the constraint on the small firm is more likely to be binding. The profits obtained by the duopoly depend on the amount of production it withholds from the market, so the large firm contributes more than the small firm. Larger firms are less likely to be liquidity constrained which increases their patience in bargaining and reduces their incentive to defect. Firms which produce a large fraction of the output of an industry (and which are dishonest to boot) are of course rare. Smaller firms are more numerous so each one is expendable. The large firm may be able to form a duopoly with a third firm. This advantage for the large firm could be lost if it defects from an agreement with the smaller firm reducing its incentives to deviate.

It is extremely unlikely that the smaller firm in a duopoly could bargain for half of the gains from restraint of trade. Therefore smaller firms are likely to gain more from defecting. Their incentive compatibility constraint is more likely to bind. If there is a duopoly and only one firm is indifferent between defecting and keeping its promise, it is probably the smaller firm.

This section has two conclusions; 1. if incentive compatibility constraints bind, the larger firm in a duopoly will use a smaller fraction of its capacity and probably receive a lower return on capital 2. if only one incentive compatibility constraint binds it will be the incentive compatibility constraint of the small firm.

IV INVENTORIES

Thus far I have only discussed duopolies which produce a non-storable good. When storage is possible firms may hold strategic inventories; inventories of the good which are liquidated if the other firm defects and which increase the severity of the "punishment" for defection. The arguments of section II suggest that the larger of the two firms will have a greater need for strategic inventories than the smaller firm, since in the cooperative equilibrium the incentive compatibility constraint of the smaller firm is tighter. In other words the difference between profits in the cooperative equilibrium and profits obtained by defecting is higher. In fact the larger firm needs a larger strategic inventory proportional to its sales than the smaller firm.

I will assume that the cost of holding inventories I is equal to interest on the initial expenditure for inventories plus the cost of replacing depreciated inventory $(r+\delta)mI$. I assume that firms can observe production and inventories, so the level of inventories can be negotiated and (possibly) enforced by the threat of returning to the Cournot-Nash equilibrium. I will also assume that if a firm chooses to sell their inventory either because it is defecting or because the other firm has just defected, it will sell its entire inventory.

The sale of the inventory held by the other firm imposes an additional cost of defection. Inventories directly increase the profits of defection in two ways, the firm profits from the sale of the inventory and it saves the cost of replenishing depreciated inventory. In other words if firm 1 holds inventories I_1 profits in the cooperative equilibrium are reduced by δI_i each period. Its profit in the period in which it defects is increased. Its profits in the period after it defects is decreased by bI_2K_1. Note that, if inventories are proportional to capacity, the additional cost of defection imposed by strategic inventories is the same for the two firms.

The additional profit obtained by firm i if it sells its inventory when it defects is given by equation 22

22) extra $profit_i = [a - bs_j - 2bK_i]I_i - \{I_i^2(b)\}$

where the term in square brackets is the derivative of profits with respect to additional sales of a firm which is already selling all it produces, I_i is the inventory remaining to be sold and the term in braces is the loss due to the second derivative of profits with respect to sales (-2b).

According to the model of bargaining described above (with either or any weight on the profits of the two firms) the reduction in profits due to the cost of replacing depreciated inventories would be considered in negotiating the level of output allowed the two firms. This means that the difference between profits in the cooperative equilibrium (including the cost of replacing depreciated inventories) will be proportional to capacity if bargaining power is proportional to capacity and equal if bargaining power is equal. The cost of holding inventories is the sum of the cost of replacing depreciated inventories and interest on the original cost of building up inventories. The second term is a sunk cost. The present value of $PC_2 - PNC_2$ is greater than $PC_1 - PNC_1$ by $m(I_2-I_1)$ in order to compensate the large firm for building up larger inventories. Since the model is stationary this is achieved by allowing the larger firm an additional $r^*m(I_2-I_1)$ of profits per period. So if the large firm has at least as much bargaining power as the small firm equation 23 holds

23) $PC_2 - PNC_2 - (PC_1 - PNC_1) \geq rm(I_2-I_1)$

This means that the cost of returning to the Cournot-Nash equilibrium is greater for the firm with larger inventories even if the firms have equal bargaining power and the price is joint profit maximizing.

Under the assumption of equal bargaining power, the difference in the incentive compatibility conditions is changed by the addition of the difference in the cost of the inventories the difference in the profits obtained by selling inventories and the subtraction of the cost imposed by the other firm when it sells its inventory as part of the punishment. This gives equation 24

24) $dif \geq + mI_2 - mI_1 - bK_1I_2 + bK_2I_1 + [a - b\,s_2 - 2bK_1]I_1 - I_1^2\,(b) -$

$[a - bs_1 - 2bK_2]I_2 + I_2^2(b)$

Equation 24 implies that the larger firm must hold more inventory in proportion to its sales than the smaller firm. In any case it is clear that the larger firm must hold a larger inventory than the smaller firm so the difference in the incentive compatibility conditions is described by inequality 25

25) dif $> bK_2I_1 - bK_1I_2 + [a - b s_2 - 2bK_1 - m]I_1 - [a - bs_1 - 2bK_2 - m]I_2$

Inequality 12 implies that

26) dif $> bK_2I_1 - bK_1I_2 + b s_2I_1 - 2b(K_1-s_1)I_1 - bs_1I_2 + 2b(K_2- s_2)I_2$.

If inventories and sales are proportional to capacity this difference is positive implying that the small firm is holding more inventory than necessary to prevent defection or that the large firm is holding less inventory than necessary. In other words the large firm must hold more inventory proportional to its capacity (and sales) than the small firm.

If the large firm uses as smaller fraction of its capacity as it would if e.g. bargaining power were equal then it must hold larger inventory proportional to sales. If $s_2I_1 = s_1I_2 > 0$ then inequality 26 becomes inequality 27

27) dif$/(s_1I_2) > (K_2/ s_2) -(K_1/s_1) + (K_2- s_2)/ s_2 - (K_1-s_1)/s_1 > 0$

That is if inventories are proportional to sales (and are not zero) either the small firm is holding a larger inventory than necessary or the large firm is holding a smaller inventory than necessary.

The supergame theoretic model of strategic inventories clearly implies that the larger firm in a duopoly will hold a larger inventory in proportion to sales than the smaller firm in the duopoly. It is reasonable to suppose that the same logic applies to oligopolies with more than two members. Furthermore it is very likely that only the largest firms in an industry will collude. Since it is difficult to enforce cooperation of small firms it is likely that large firms will allow them to free ride which would imply that small firms need not hold strategic inventories at all. The model suggests that large firms will hold greater inventories compared to sales than small firms in the same industry. This prediction can be tested for industries in which data on inventories held by firms are available e.g. the car industry.

V UNCERTAIN DEMAND

Would either firm in a collusive duopoly choose to act as the swing supplier insuring the other constant sales ? The results reported in the earlier section strongly suggest that if either firm would do so it would be the larger of the two. If the smaller firm is undecided whether to defect or keep its promise, the large firm would benefit by insuring its demand. One simple way to do this would be for the large firm to charge a slightly higher price so demand for the small firms product would be rationed.

If information about demand is symmetric, the agreed quantities can be made a function of expected demand. An automatic mechanism is only necessary if information is asymmetric.

One important form of asymmetric information is asymmetric information concerning future demand -- that is demand in periods after the one for which the firms are deciding which output to produce. This affects the current decision only because it affects the cost of the "punishment" for returning to the Cournot-Nash equilibrium from the negotiated equilibrium.

If the smaller firm knows that in expectation demand will be very low in second period while it is deciding what output to produce in the first period and the larger firm does not and will not learn before the second period, the smaller firm will break the collusive equilibrium. If the larger firm does not learn about the decline in demand before it decides how much to produce in the second period it will produce S2 if the smaller firm has not finked in the first period and K_2 if the small firm has finked. If the small firm expects that demand will be very low in the second period then the anticipated cost of the drop in demand will be less if it has finked than if it has cooperated in the first period. For example if a is so low that $a - bS2 - m < 0$, then the smaller firm's profit will be zero in any case, so it will not lose profit in the second period by finking in the first. Even for demand higher than this very low level, the cost of returning to the static Cournot-Nash equilibrium will be reduced by the decline in demand. If incentive compatibility constraint of the smaller firm was binding even for normal a, it will violate the collusive agreement in period 1.

An anticipated decline in demand may also reduce the cost of defection of the larger firm, but as argued above, it is less likely for the incentive compatibility constraint of the larger firm to be binding.

To avoid the danger that anticipation of a sharp drop in demand in the future will cause the smaller firm to defect, the larger firm could guarantee that demand for the product of the smaller firm not fall too low by refusing to cut its price as much as the small firm if demand is very low. In this case the smaller firm will sell all that it produces, but the larger firm will inventory some of its product. Even if the carrying cost of inventories is so high that neither firm normally holds them, the larger firm will still hold inventories in periods of extremely low demand.

This argument requires the assumption that the larger firm will not learn about the imminent decline in output before it decides how much to produce in the second period. If it learns, and if the smaller firm has not violated the agreement in the first period, it will reduce output enough to keep the smaller firm from violating the agreement in the second period. This actually implies a still greater incentive to cooperate in the first period than the smaller firm would have if there were no decline in demand.

It is however not necessary to assume that the smaller firm does not consider warning the larger firm about the decline in demand. If the larger firm granted the smaller firm a larger share of output when the smaller firm warned of an expected decline in demand, the smaller firm would have an incentive to lie. If its information is imperfect, it could not be caught with confidence.

For asymmetric information to cause the smaller firm to fink, it is not necessary for the specific form of asymmetric information described above to be the only form of asymmetric information. It is only necessary for it to exist.

The results described in this section are not very useful. The conditions required for the larger firm to benefit by refusing to cut prices as much as the smaller firm are extreme and might never occur. In any case, they are likely to be rare, making it difficult to observe such behavior. Furthermore it is impossible to know if price differences are the result of collusion or differences in quality. The section amounts more nearly to a suggestion to oligopolists about how they might better exploit consumers than a suggestion of how to test whether firms are colluding.

VI GENERALIZATIONS

The models used above all assume that both firms have equal marginal cost (at least as a function of capacity utilization). The conclusions are more general. Similar results obtain when the two firms each have constant marginal cost (and infinite capacity) and one firm has lower marginal cost than the other. Assume each firm agrees to reduce its output by the same fraction of its Cournot/Nash output. The incentive compatibility constraint of the less efficient firm is more difficult to satisfy. If it is just binding, the incentive compatibility constraint of the more efficient firm will not bind. If incentive compatibility constraints bind at all, the more efficient firm will have to reduce its output proportionally more than the less efficient firm.

This result directly leads to the conclusion that the incentive compatibility constraint of the more efficient firm does not bind in the Nash bargain collusive agreement. In the Nash bargain with equal weights, the more efficient firm reduces output proportionally less than the less efficient firm.

Similar results obtain if prices instead of quantities are the strategic variable. The outcome without collusion and the benefits of deviation are very different of course. Nonetheless, in an incentive compatible collusive agreement resulting form nash bargaining with equal weights, the incentive compatibility constraint of the more efficient firm does not bind.

Thus the conclusions that firms with higher output hold proportionally greater strategic inventories and may serve as swing producers follow from these models as well. Proofs of these claims are available from the author on request (hand written).

VII CONCLUSION

Supergame theoretic models of asymmetric collusive duopolies generate several testable predictions. All result from the fact that it is more difficult for a large firm to enforce cooperation by a small firm than vice versa. As a result, the larger firm in a collusive duopoly will hold larger excess capacity and larger strategic inventories. The large firm may also agree to act as a swing producer meeting fluctuations in demand. These predictions are supported by qualitative descriptions of successful cartels (Eckbo 1976). It would be worthwhile to test them with data on large firms in concentrated industries. If the predictions are confirmed the use of the models to explain the cyclical behavior of markups and inventories will be supported. If the predictions are not confirmed many explanations are possible; firms might not be colluding, incentive compatibility constraints might not bind or the models and solution concepts might be incorrect. In any case doubt would be cast on the use of these models.

REFERENCES

Abreu, Dilip (1986) "External Equilibria of Oligopolistic Supergames," Journal of Economic Theory vol 39, pp 191-225.

Barsky, Robert; and Solon, Gary (1985) "Real Wages Over the Business Cycle," NBER Working Paper # 2888.

Bils, Mark (1985) "Real Wages Over the Business Cycle," Journal of Political Economy vol 93 pp 666-89.

Bils, Mark (1987) "The Cyclical Behavior of Marginal Cost and Price," American Economic Review vol 77 pp 838-57.

.Bils, Mark (1989) "Pricing in a Customer Market," Quarterly Journal of Economics November 1989.

Domowitz, I; Hubbard, R.G.; and Petersen, B. (1988) "Market Structure and Cyclical Fluctuations in U.S. Manufacturing." Review of Economics and Statistics.

Donsimoni, Marie-Paule (1985) "Stable Heterogenous Cartels," International Journal of Industiral Economics Vol 3 pp 451-467

Donsimoni, Marie-Paule; Economides, N.S. and Polimarchakis, H.M. (1986) "Stable Cartels," International Eonomic Review Vol 27 pp 317- 327.

Eckbo, Paul L. (1976) The Future of World Oil Cambridge:Ballinger.

Friedman, James (1983) Oligopoly Theory Cambridge:Cambridge University press.

Friedman, James (1971) "A Non-Cooperative Equilibrium for Supergames," Review of Economic Studies vol 38 pp 1-12.

Fudenberg, Andrew and Maskin Eric (1986) "The Folk Theorem in Repeated Games With Discounting and with Incomplete Information," Econometrica vol 54 pp 533-54.

Martin, S. (1990) "Fringe Size and Cartel Stability." EUI Working Paper ECO no. 90/16.

Osborne, M. J.; and Pitchik, C. (1983) "Profit Sharing in a Collusive Oligopoly," European Economic Review vol 22 pp 59-74.

Rotemberg, Julio and Saloner, Garth (1985) "StrategicC Inventories and the Excess Volatility of Production," Sloan School of Management Working Paper # 1650-85.

Rotemberg, Julio and Saloner, Garth (1986) "A Supergame Theoretic Model of Business Cycles and Price Wars During Booms," American Economic Review vol 76 pp 390-407.

Rotemberg, Julio and Saloner, Garth (1989) "The Cyclical Behavior of Strategic Inventories," Quarterly Journal of Economics vol. pp 73-97.

Rotemberg, Julio; and Woodford, Michael (1989) "Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity" NBER Working Paper # 3206.

Rubenstein, Ariel (1982) "Perfect Equilibrium in a Bargaining Model," Econometrica vol 50 pp 97-110.

Schmalensee, Richard (1987) "Competitive Advantage and Collusive Optima," International Journal of Industrial Organization vol. 5 pp. 351-367.

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