

Using Relative Profit Incentives to Prevent Collusion

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Abstract. This paper describes a new economic method for preventing oligopoly collusion. The method eliminates incentives for collusion by making managerial compensation depend on relative profits rather than absolute profits. This alteration of managerial incentives sets up a zero-sum game among the firms in an industry, yielding the result that firms no longer have incentive to collude, either actually or tacitly, with regard to prices or outputs. The method also ameliorates the imperfectly competitive outcomes which can result from even noncooperative oligopoly interactions.

Key words: Oligopoly, collusion, relative profits, zero-sum game, managerial incentives.

Introduction

The purpose of this paper is to present an alternative method for preventing collusion.¹ The method eliminates incentives for both actual and tacit collusion, and ameliorates the imperfectly competitive outcomes which can result from even non-cooperative oligopoly interactions. The method prevents exploitation of oligopoly power, but is not a general cure for the market power problems of either strict monopoly or monopolistic competition.

Section I introduces and verbally describes the basic method of providing relative profit maximizing incentives for owners and managers of business firms. Section II reviews some related literature. Section III illustrates the method using a particular mathematical example. Section IV discusses some practical concerns related to implementing the method. Section V focuses on how firm owners can be prevented from making management stress absolute profits over relative profits. Section VI concludes. Three mathematical appendices derive: (A) the optimal weighting of rival firms' profits under a relative profit incentive scheme; (B) short-run equilibrium; and (C) Bertrand equilibrium for differentiated products.

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¹ NOTICE OF PATENT PENDING: This paper describes a method of economic regulation for preventing collusion upon which the author and inventor has applied for a patent. A patent on this invention, if such should be granted, would only restrict actual use of the described invention; it would not restrict in any way the verbal or written discussion, description, or criticism of that invention.

I. Basic Method

In an industry structure with only a few firms, collusion is a serious possibility, even when it is illegal. Tacit collusion, which does not require illegal communication among conspirators, can also occur.

The basic concept which underlies this proposed method is the perception that causing managers of firms to participate in a zero-sum game, or its equivalent or near-equivalent, will hinder or prevent cooperation or collusion among the managers of different firms. In a zero-sum game it is possible for one firm's manager to gain only if another firm's manager loses, since there is only a fixed quantity of rewards to go around. In a nonzero-sum game it is frequently possible for everyone to gain through cooperation (collusion) as opposed to noncooperation, since cooperation may increase the total quantity of rewards available to go around.

A zero-sum game for industry may be instituted by forcing firms as a whole to participate in a zero-sum game and/or by arranging zero-sum compensation arrangements for the managers of different firms. When the goal of firms is maximizing profits, instituting a zero-sum game in profits means that firms are motivated to maximize relative profits rather than absolute profits. That is, firms attempt to maximize the difference of their own firm's absolute profits relative to an average of other firms' absolute profits. Alternatively and equivalently, firms attempt to maximize the difference of their own firm's absolute profits relative to the average absolute profits of a group of competing firms, of which group the firm is a member.

A good way to institute a zero-sum game among firms in an industry is by motivating managers to seek relative profits rather than absolute profits. The usual way to motivate managers to pursue a particular goal is to pay managers in accordance with success in achieving that goal. If the goal is to maximize absolute profits, managers should expect to receive more compensation, the higher profits turn out to be. By altering the rules for managerial compensation in the appropriate way, we can make sure that managers are motivated to maximize relative profits rather than absolute profits.

The key to understanding this method rests upon the seemingly trivial observation that successful collusion increases the absolute profits of firms, but does not increase the relative profits of firms. When firms collusively raise prices, the relative profits of each firm cannot increase on average. Only one of two things can happen: Either (1) absolute profits of each firm rise equally and relative profits of each firm stay the same, or (2) the absolute profits of each firm do not rise equally, in which case some firms gain relative profit and some firms lose relative profit. If the second case holds true, any firm which loses relative profit from the collusive agreement will want to cheat (assuming it seeks relative profit), since it gains relative profit in the short run by cheating and it gains relative profit in the long run by breaking up the collusive agreement. If the first case holds true, no firm gains relative profit by maintaining the collusive agreement in the long run, and every firm gains relative profit by cheating in the short run. In a relative profit

maximizing industry there is no incentive for all the firms to enter into or maintain any collusive agreement. Competitive behavior must result.

Setting up a zero-sum game in profits does not in any way require placing any cap or limitation on the amount of absolute or relative profit which any individual firm may earn. Rather, there is simply a definitional change in the type of profit which a firm or firm manager is expected to maximize. The main difference between absolute profit maximizing (APM) firms and relative profit maximizing (RPM) firms is that RPM firms are not motivated to collude. In the absence of collusion, absolute profit and relative profit are very similar. RPM firms are just as strongly motivated as APM firms to seek other sources of profit, such as reducing costs of production or improving product quality. RPM firms are not deliberately inefficient nor do they try to slow down technical progress. They merely refuse to collude, even tacitly.

Government is assumed able to observe costs and revenues *ex post*, but is not assumed able to observe either demand curves or cost functions. The proposed regulation is not heavy-handed. Price controls, profit controls, central commands, and the like are no part of the proposal. Under the relative-profit scheme of regulation, firms are perfectly free to try to make as much profit as they can, set whatever prices they wish, sell whatever products they wish, and to enter or exit industries and product lines as they please. Application of the RPM regulatory scheme need not extend beyond those firms which are most likely to collude (i.e., the largest firms within an oligopoly industry). Competitive industries, of course, do not need to be included (though no harm would come if they were).

II. Review of Some Related Literature

Only in Donaldson and Neary (1984) does there first appear a suggestion that the principles of relative profit maximizing might be put to practical use by altering the incentives of firms or managers. Donaldson and Neary suggest that relative profit maximizing managers in a "socialist industry" composed wholly of government-owned firms can achieve efficient outcomes with a minimum of administrative supervision by a central planner. They also prove numerous game theory propositions in this connection. Although they indirectly allude to the anti-collusive features of the incentive scheme, they never directly state this property outright. Consequently, they appear to have overlooked the possibility of extending the scheme to prevent collusion in privately-owned or "capitalist" industries. Also, they appear to impose the unwarranted restriction that each manager must be paid dollar-for-dollar for each dollar of relative profit which a firm earns (p. 102).

Two basic propositions in the Donaldson and Neary (1984) paper are worth special mention. The first is that RPM firms producing multiple or joint products will tend to produce at minimum cost and price efficiently (pp. 104–5, 109–10). This means that the incentive scheme is capable of being applied, not only to single-product firms and industries, but also to multi-product firms and industries.

Secondly, RPM firms, unlike their APM counterparts, have little or no strategic incentive to increase their market shares in a cost-inefficient manner by installing excess capital (pp. 105, 107–9).

The theoretical suggestion that firms with absolute profit incentives might under certain (presumably rare) circumstances try to behave as if they desired to maximize relative profits appears to have been made as early as 1960. Bishop (1960), describing the alleged “warfare” of oligopolists in the absence of collusion, Shubik and Levitan (1980), describing “beat-the-average” games, and Jones (1980), describing the outcome of a classroom game, each derive first-order conditions for a constant-sum game in relative profits. Jones also derives second-order conditions. Two reasons are suggested for such behavior: (1) Businessmen might be naturally rivalrous, caring more about relative position than absolute position, or (2) businessmen may be carrying out threats in order to elicit more favorable collusive agreements from their rivals in the future. These three works do not suggest any practical application for the mathematical principles of relative profit maximizing.

Although they do not anticipate the present subject matter, several other papers are worth mentioning. Holmstrom (1982) and Aron (1988) explore the use of relative performance evaluations for the quite distinct purpose of attempting more accurate evaluations of managerial performance. Gibbons and Murphy (1990) ask whether, in fact, managers tend to be paid according to relative performance. Fouraker and Siegel (1963) and Vickers (1985) consider relative profit goals and incentives of a different type, namely maximization of the difference between absolute profits of own firm and *total* absolute profits of rival firms, rather than *average* absolute profits of rival firms. Fershtman and Judd (1987) and Sklivas (1987) also consider alternative managerial incentives, but not relative profit incentives. Shleifer (1985) and Tam (1988) describe what may be the best currently known alternatives for regulating oligopoly markets, aside from antitrust enforcement or structural reform. Both of these alternatives require the regulation of prices, whereas the present method does not.

In summary, none of the previous literature suggests that relative performance incentives can be used as a general method for preventing collusion.

III. An Illustrative Example

Let G be some statistic which describes something about a firm. If the firm's managers are rewarded for achieving higher levels of G , then maximizing G will be the firm's goal or objective.

For purposes of this example, assume that there are N ($N \geq 2$) identical firms. Each firm produces a single, homogenous product at a constant marginal cost of C . The market demand is linear, with $P = A - bQ$, where $Q = \sum Q_i$ and Q_i is firm output. Assume that each firm pursues an identical goal function, which has a coefficient of unity in own firm profits and a coefficient of W in rival firm profits. The goal function for firm i and rival firm(s) j looks as follows:

$$\begin{aligned}
 G_i &= \pi_i + W \sum_{j \neq i} \pi_j \\
 &= \pi_i + W(N-1)\pi_j \\
 &= (PQ_i - CQ_i) + W(N-1)(PQ_j - CQ_j)
 \end{aligned} \tag{1}$$

If $W = 0$, then the firm's goal is simply to maximize its own economic profit. This is the absolute profit maximizing (APM) goal. If $W = 1$, then the firm has a joint profit maximizing (JPM) goal. If all N firms have JPM goals, the industry will surely collude. On the other hand, if $W = -1/(N-1)$, then the firm has a relative profit maximizing (RPM) goal. The RPM goal is calculated by starting with own firm profits and subtracting off a weighted average of the $N-1$ rival firm profits.

If we assume noncooperative behavior and Cournot conjectures, firm i maximizes its goal function by choosing Q_i such that:

$$\begin{aligned}
 \partial G_i / \partial Q_i &= (P - C) + (\partial P / \partial Q_i)[Q_i + W(N-1)Q_j] = 0 \\
 &= (A - bQ_i - b(N-1)Q_j - C) \\
 &\quad - b(Q_i + W(N-1)Q_j) = 0
 \end{aligned} \tag{2}$$

For a symmetric, noncooperative equilibrium, assume that $Q_n = Q_i = Q_j$. Define $W_M = 1 + W(N-1)$. We can calculate the following quantities, price-cost margins, absolute profits, and goal fulfillments for each firm:

$$\begin{aligned}
 Q_n &= (A - C) / [b(N + W_M)] \\
 P_n - C &= (A - C)W_M / (N + W_M) \\
 \pi_n &= (A - C)^2 W_M / [b(N + W_M)^2] \\
 G_n &= (A - C)^2 W_M^2 / [b(N + W_M)^2]
 \end{aligned} \tag{3}$$

Now, assume instead that each firm pursues a collusive ("monopoly") equilibrium, in which each firm attempts to maximize its goal function under the assumption that all firms cooperate by setting the same level of output (Q_M) and receiving the same level of profit (π_M). The goal function takes the form:

$$\begin{aligned}
 G_M &= [1 + W(N-1)]\pi_M \\
 &= W_M \pi_M \\
 &= W_M(PQ_M - CQ_M)
 \end{aligned} \tag{4}$$

When $W > -1/(N - 1)$, $W_M > 0$, so that joint goal fulfillment is equivalent to maximizing joint absolute profits. When $W < -1/(N - 1)$, $W_M < 0$, joint goal fulfillment requires the minimization of joint absolute profits, or the maximization of joint losses. When $W = -1/(N - 1)$, $W_M = 0$, we have a zero-sum game in relative profits. When $W_M = 0$, collusion can in no way improve the sum of relative profits for all N firms, since these must always add to zero. When $W_M = 0$, there is no incentive for all N firms to collude either to raise prices or to lower prices from the prices that would exist in a noncooperative equilibrium.

In what follows, assume that $W \geq -1/(N - 1)$, so that $W_M \geq 0$ and joint maximization of absolute profits is a (weakly) plausible goal of collusion. (When $W_M = 0$, firms are collectively no better off, but neither are they collectively worse off, from collusion.) Then the collusive equilibrium has the following solution:

$$\begin{aligned}
 \partial G_M / \partial Q_M &= W_M(P - C) + (\partial P / \partial Q_M)W_M Q_M = 0 \\
 &= W_M(A - bN Q_M - C) - bN W_M Q_M = 0 \\
 Q_M &= (A - C) / [2bN] \\
 P_M - C &= (A - C) / 2 \\
 \pi_M &= (A - C)^2 / [4bN] \\
 G_M &= (A - C)^2 W_M / [4bN]
 \end{aligned} \tag{5}$$

We now consider the one-period incentive for a firm to cheat on a collusive agreement. This can be calculated under the assumption that a single firm chooses its output to maximize its own goal function, taking as given that rival firms choose the agreed-upon collusive output level:

$$\begin{aligned}
 G_C &= \pi_i + W(N - 1)\pi_j(Q_j = Q_M) \\
 &= (PQ_i - CQ_i) + W(N - 1)(PQ_M - CQ_M)
 \end{aligned} \tag{6}$$

This has solution:

$$\begin{aligned}
 \partial G_C / \partial Q_i &= (P - C) + (\partial P / \partial Q_i)(Q_i + W(N - 1)Q_M) = 0 \\
 &= (A - bQ_i - b(N - 1)Q_M - C) - b(Q_i + W(N - 1)Q_M) = 0 \\
 Q_c &= (A - C)(N + 2 - W_M) / [4bN] \\
 P_C - C &= (A - C)(N + W_M) / [4N] \\
 \pi_C &= (A - C)^2(N + 2 - W_M)(N + W_M) / [16bN^2] \\
 \pi_j &= (A - C)^2(N + W_M) / [8bN^2] \\
 G_C &= (A - C)^2(N + W_M)^2 / [16bN^2]
 \end{aligned} \tag{7}$$

The reward to a firm which colludes in a repeated game with its rivals is:

$$R_M = G_M + \sum_{t=1}^{\infty} G_M / (1+r)^t = G_M + G_M/r \quad (8)$$

The value of r depends not simply on the cost of capital and risk premia, but also includes the probability that collusion may break down, perhaps because of industry changes or government intervention. The length of the time period, t , depends on the time it takes for rivals to discover that cheating has occurred, after which collusion breaks down. The shorter the time period needed to detect cheating, the lower the value of r . The reward to a firm which cheats in period $t = 0$ and sees the noncooperative equilibrium in subsequent periods is:

$$R_C = G_C + \sum_{t=1}^{\infty} G_n / (1+r)^t = G_C + G_n/r \quad (9)$$

$R_M > R_C$ (so that collusion is sustainable) whenever the collusion/cheating ratio shown below exceeds r :

$$(G_M - G_n) / (G_C - G_M) = 4NW_M / (N + W_M)^2 > r \quad (10)$$

For a given N within the relevant range, this ratio reaches its maximum value of 1 when $W_M = N$ (JPM) and reaches its minimum value of 0 when $W_M = 0$ (RPM). The ratio rises monotonically when W_M increases from 0 to N . As might be expected, when $W_M = 1$ (APM), this ratio falls (i.e., collusion is harder to sustain) when the number of firms (N) increases.

To summarize, when firms are given RPM incentives and placed in a zero-sum game, the incentive to collude is eliminated, but the incentive to cheat on collusion is maintained. No collusive agreement can benefit all firms in a zero-sum game, and any such agreement would in any case be subject to overwhelming incentives for most or all firms to cheat. This was shown verbally in Section I and is illustrated in this section using a particular mathematical model. The details of a mathematical model can be varied endlessly, but the qualitative conclusion will always be the same, given the verbal proof in Section I.

IV. Practical Implementation

Economists traditionally present theory and presume (sometimes unrealistically) that the manner of its practice will be immediately apparent. With respect to many practical concerns which some economists and laymen have raised, some brief answers are indicated below.

1. *Would government regulators need extensive and expensive data to enforce the proposed scheme?* No. The only data needed are data on costs, revenues, profits, and managerial compensation. Since this data must be collected in any case, either

by government for tax purposes, or by accountants as a prudent way for managers and stockholders to keep tabs on a firm's activities and cash flows, it follows that the method can be implemented at little or no extra cost.

This data is readily observable, so governmental omniscience is not required to implement the method. In particular, it is not assumed that government can observe either cost functions or demand curves, nor is it assumed that government can calculate optimal prices, profits, or output levels. Hence, the RPM method can be practiced, even if government is unable (because of information limitations) to set optimal prices or quantities directly.

2. *Would the use of accounting data to measure costs, revenues, and profits cause economic distortions?* Perhaps, but a more relevant question might be, would such distortions be any greater under RPM than under APM? The purpose of the method is to prevent collusion, not to calculate true economic costs or profits. Even under current arrangements, inability to measure true economic cost prevents stockholders from motivating managers with proper incentives to maximize absolute profits. Whatever may be (for motivational purposes) the most accurate way to measure absolute profits can also be used as a good way to measure relative profits. Regardless of whether profits are calculated using accounting data or other imperfect data, collusion will be prevented, and there is unlikely to be any significant incremental effect in causing additional misallocation of resources.

3. *How does one measure "relative profit"?* Aside from accounting measures, one way to estimate absolute profit is to look at changes in the value of a firm's total outstanding stock over a period of time and make adjustments at an appropriate interest rate for dividends paid or new stock shares issued over the same period of time. Since changes in both short-term and long-term profit potential affect the firm's value, this method of ascertaining profit gives managers the least incentive to manipulate accounting procedures, or to manipulate events in response to mistaken accounting rules. To calculate relative profits by this method, one simply looks at the change in value for one firm and subtracts off a weighted average of the change in value for rival firm(s).

An alternative method for measuring relative profit makes use of a new forecasting method, described by Lundgren (1995). This method provides efficient incentives for unbiased human forecasts of any variable value, including the future absolute profits or relative profits of any firm or any subcomponent of a firm, and such forecasts can be made as free of accounting biases as stock values. An advantage of the forecasting method is that it can be used to separate out the industry-specific profits of a conglomerate operating in several industries.

4. *How does one apply the relative profit concept to industries which contain multi-industry conglomerates?* Most multi-industry conglomerates adopt the multi-division form of organization, in which each industry division is operated essentially as a separate profit center, with separate accounting for each industry of operation. If the conglomerate operates in unrelated industries, there is unlikely to be any economy of scale or scope that would be wasted if the conglomerate

were required to break itself up into single-industry parts. If a break-up is deemed undesirable because of economies of scale or scope, and if it is infeasible to issue separate securities for each industry subsidiary of the firm, then one can either use accounting techniques or use the forecasting technique described in Lundgren (1995). If a firm simply produces multiple (but closely related) products, the firm is best understood as producing in a single industry – a circumstance which requires no special treatment, as shown in Donaldson and Neary (1984, pp. 104–5, 109–110).

5. *How does one define the “market” or “industry” for purposes of imposing the zero-sum game?* Since it is not the purpose of the scheme to determine legal culpability for monopolization, but simply to eliminate incentives for collusion, it is not necessary to answer the tricky question of how broadly or narrowly the market should be defined. It is generally preferable to define the industry/market rather narrowly, so that only a very few, very similar firms are placed in each zero-sum game. That is, if there is a broadly defined industry with several firms, it is generally preferable to impose more than one zero-sum game on the several firms, by grouping the firms into more narrowly defined sub-industries, and imposing a zero-sum game on each of the smaller groups. Unlike under current antitrust law, it is not necessary to inquire whether more distantly related firms are actually part of the same “market”.

6. *How does one sustain incentives for innovation and technological progress?* Innovations may be either costless or costly, and may be either patentable or unpatentable. If innovations are costless, we may presume that relative profit maximizers will adopt them, since profit maximization implies cost minimization. If innovations are costly, but patentable, the patent law provides incentive for innovation. Since RPM incentives are designed to induce competition, they should not be applied to situations where monopoly, and hence absolute profit maximizing, is the preferred public policy. Fortunately, both absolute profit and relative profit are measured in compatible money units, so there is nothing to prevent the institution of APM incentives for patented activities and RPM incentives for unpatented activities, even with respect to the same manager in the same firm.²

If innovations are costly, but unpatentable, RPM firms still have an incentive to reduce costs, if gains from innovation can be captured for a period of time until competitors follow suit. This incentive is proportional to firm output. The conventional Schumpeterian “wisdom” that a competitive industry is less innovative than an oligopolistic industry confounds the influence of firm size with the competitive/noncompetitive nature of firm interaction. It is mainly the size of firm output, not the size of a collusive price-cost margin, which determines the size of the incentive to reduce unit costs.

² There are various ways this can be done. For example, if firm A has a patent and firm B is a rival, any royalty payment from firm B to firm A would not be counted against either firm A or firm B in the calculation of relative profits. A complete exposition would require a separate paper.

7. *How does one prevent RPM industries from sustaining chronic losses?* Chronic losses would occur only if marginal cost lies consistently below average cost for a particular industry. In such case, the industry can be made viable by offering an industry lump-sum subsidy in the exact amount of the industry's economic losses. Lump-sum subsidies may be distributed equally to all firms in a zero-sum group without affecting relative profits, and hence without inducing behavior to manipulate the size of the subsidy. Financing the subsidy through general revenues yields marginal cost pricing. Financing through a special industry tax yields average cost pricing.

8. *How does one ensure that RPM firms do not sabotage rival firms' operations?* Since relative profits rise when rival firm profits fall, there is arguably an increased incentive to sabotage rival firm operations. An increased incentive to cause sabotage need not imply a significant increase in actual sabotage. A situation of mutual sabotage can only arise if legal penalties are very weak, since rival firms have incentive to investigate, report, and prosecute sabotage activities which reduce their levels of profit.

Nevertheless, even if we were to suppose that serious sabotage problems would arise from an unmodified RPM incentive scheme, it is possible to modify the incentive scheme slightly so as to eliminate the sabotaging incentives. This modification would require a deduction in managerial compensation which offsets (or further penalizes) any gain in managerial compensation resulting from any gain in relative profits due to sabotage occurring in rival firms, even if legal culpability for the sabotage cannot be established. In other words, one may convert the zero-sum game into a negative-sum game, if sabotage is observed. (One can apply the same reasoning to lawsuits.)

9. *How does one ensure that corporate managers will not evade the regulation of salary policies?* The regulation of managerial compensation has nothing to do with the total amount of the salary and bonuses, but only the methods of their calculation. Even if we suppose that the value of relative profits is lower, on average, than the value of absolute profits, the noncontingent salary component of a manager's compensation can always be raised to compensate. No reduction in the average levels of managerial compensation is required. For the same level of risk and expected compensation, managers do not care whether bonuses are contingent on relative profit or absolute profit.

10. *Does the scheme represent an unwarranted intrusion into managerial compensation policies which have heretofore been unregulated?* The proposal does not actually require government to *determine* the managerial incentive schemes. It simply requires that the contingent part of any managerial incentive scheme must be based on relative firm performance, rather than absolute firm performance. In order to prevent the incentive for managerial collusion, it is not necessary that government determine the overall level of managerial compensation, nor is it necessary that government determine and implement any particular method for measuring

relative firm performance. The minor intrusion, if it be such, is justified by the important public purpose at stake: Preventing collusion.

11. *How does one prevent collusion among managers to reduce managerial effort levels?* Instituting a zero-sum game in managerial income does not mean instituting a zero-sum game in managerial effort levels, so collusion to reduce managerial efforts is at least conceivable. However, collusion to reduce effort levels is not a serious threat, since a) managers of firms typically work in separate locations, and b) the work of managers consists mainly of mental efforts. Therefore, since managerial effort is essentially unobservable, any agreement to reduce effort levels cannot be easily monitored or enforced by colluding managers.

However, simply for argument's sake, suppose that managerial effort is actually (at least partly) observable. For example, suppose effort can be measured based on hours spent "on the job". In that case, one can pay managers based both on absolute effort and on relative performance. If the compensation rate for effort is made high enough, managers will no longer have incentive to collude to reduce effort levels, even if such collusion could be made perfectly enforceable.

12. *How does one ensure that firm owners will not find ways of making management stress absolute profits over relative profits?* This is the subject of the next section.

V. Owners, Managers, and Incentives

There are at least two ways of instituting relative profit incentives for firms. First, top management (including the board of directors) can be given long-term compensation contracts based on relative performance. Secondly, one can impose the zero-sum game in profits on whole firms (owners), and not just managers. Government may adopt only the first set of measures, only the second set, or both sets simultaneously.

The second method can be implemented by 100% taxing (subsidizing) the combined economic profits (losses) of an industry and allocating the tax (subsidy) equally to each firm. The tax (subsidy) would be on *industry* profits, *not* individual *firm* profits. As a result of the industry tax/subsidy scheme, after-tax profits to owner-shareholders are equivalent to pre-tax relative profits, which means owners will try to maximize relative profits rather than absolute profits. Although this method appears economically viable, it may not be politically palatable, given the potential for redistributions of income between stockholders and the government.

In firms or industries where owners and managers are one and the same, these two methods are essentially equivalent. No choice is possible. However, most important oligopoly industries are probably composed of large corporations which maintain a separation between ownership and direct managerial control. This well-known aspect of the internal structure of the modern corporation presents an interesting avenue by which government can enforce antitrust policy. Rather than impose relative profit incentives directly upon owners through taxes and sub-

sidies, government can influence firm behavior simply by altering the incentives of management.

However, if owners are not made the direct subjects of taxes and subsidies which impose relative profit incentives, this raises the issue of whether absolute wealth maximizing stockholders can somehow reimpose APM incentives on RPM managers. The current state of corporate affairs is that managers, not stockholders, basically control the large corporation. Managers effectively appoint the boards of directors, to whom they are ostensibly responsible. Indirectly, through their choice of board members, managers set their own salaries. Managers have no incentive to change this state of affairs.

Stockholders are numerous and dispersed. Individually, most stockholders do not have enough votes to unseat management. Obtaining collective action to unseat management requires significant expense, which most stockholders find too costly to undertake. Controlling management is a "public good" for all stockholders, which most stockholders find rational to "free ride" upon by not attempting to provide it. The only stockholders who might have an incentive to undo management policies are the largest or principal stockholders. The remaining stockholders are of no consequence, except as voters who might side with the principal stockholder in any fight against management.

Consider, therefore, an industry in which the top two, three, or four firms have been placed into a zero-sum game in terms of managerial incentives. Each firm has a different principal owner. If the same person or entity is a principal owner in two or more of the top firms in an oligopoly industry, this should be regarded as an antitrust violation, just the same as interlocking directorates are so regarded. Hence, we assume different principal owners. Any conspiracy to undo the relative incentive scheme must involve the principal owners, since the managers themselves have no such incentive.

To be effective, the conspiracy must convert all or most managers from relative profit goals to absolute goals. To convert only one manager to absolute profit goals would not generate the kind of collusion among business firms which could substantially raise prices and profits, and thereby make the conspiracy (with its attendant risks) worthwhile from a private perspective. The conspiracy must therefore involve the principal owners of different firms acting in combination. The principal owners, being already wealthy, will not rationally risk jail time simply to increase their wealth still further. Suppose, nevertheless, that the principal owners attempt a conspiracy. What means would they use to influence management?

There are basically only two avenues by which the principal owners might try to influence management: compensation and employment. Either avenue may be pursued overtly or covertly.

First consider overt operations. The principal owner persuades stockholder voters to alter the conditions of employment or compensation. For example, the principal owner might use the annual stockholder meetings to directly hire or fire the manager, according to whether the manager pursued or failed to pursue collusive

policies alongside other firms. Alternatively, the annual meetings might be used to raise or lower the base salary for future employment in a manner designed to undo the relative profit incentives paid in previous years.

Use of the annual stockholder meetings for either purpose would be an unusual or abnormal business practice. Use of the annual meetings for these purposes by an RPM firm would clearly be a suspect practice, prompting an antitrust investigation. More simply, use of a stockholder meeting to directly determine managerial employment or compensation might be made a *per se* antitrust violation, when performed by an RPM firm.

Thus, the following is recommended for instituting RPM incentives on management: Both the managers and the boards of directors are given long-term contracts containing relative performance incentives, which are not altered from year to year in a manner that might allow an owner to undo the RPM incentives. Any part of the compensation (including stock holdings or stock options) which is contingent on the firm's performance must be based on relative performance, not absolute performance. All compensation and compensation arrangements of managers and directors of RPM firms are disclosed to the antitrust authorities. Managerial employment is determined by the board of directors (all of whom are paid according to RPM incentives), not by either stockholders or principal owners, unless the principal owners have been converted to RPM incentives. The directors have overlapping terms, and are not all elected at once.

In situations where a principal owner (or other stockholder) wishes to have an active role in management or on the board of directors of an RPM firm, such owner or stockholder must have his stockholdings converted into assets which provide RPM incentives. This can be accomplished either by shorting the stock of rival RPM firms, and/or by imposing a tax/subsidy on the stockholder which mimicks the change in value of the stock in rival RPM firms. If the principal stockholder desires to be a passive investor, this change in incentive is not required.

Consider now possible covert operations. Assume that the principal owner has not acknowledged any active interest in the corporation, and has not been converted to RPM incentives. How can a principal owner with APM incentives undo the RPM incentives of firm managers? There are only two possibilities: threats and bribes. Threats are particularly likely to be reported to the antitrust authorities, could result in extra jail time, and will presumably not be resorted to. This leaves bribery.

The rich stockholder may choose to bribe either the manager or the directors. The manager might be bribed to behave collusively. The directors might be bribed to hire and fire managers based on willingness to collude. Bribing the directors is likely to be cheaper, but also less effective and more likely to be reported. Even if successful, bribing the directors to fire a manager is particularly likely to be reported by the manager. This leaves only bribing the manager directly.

A conspiracy by principal owner(s) will not stop at trying to institute APM incentives on RPM managers. Rather, the rational goal would be to attempt to institute joint-profit maximizing (JPM) incentives on the managers. Bribing the

managers of all the important firms in the industry to institute JPM incentives is the only procedure that would guarantee collusion. Re-instituting APM incentives merely provides the opportunity for collusion, but does not guarantee its occurrence.

The possibility that principal owner(s) might bribe the manager(s) of APM firms to collude, or provide them with JPM incentives exists even today. Yet one rarely (or never?) hears of principal owner(s) attempting to bribe or covertly pay firm managers in this manner. If such behavior does not happen when firm managers are paid according to APM incentives, why should it happen if managers are paid according to RPM incentives?

In short, an illegal conspiracy of stockholders to re-impose absolute profit incentives onto firm managers is unlikely. The small stockholder has little influence and insufficient incentive to launch such a conspiracy. The large stockholder is too wealthy to want to risk jail time. Any such conspiracy would have to be explicit (and therefore detectable), not merely tacit.

VI. Conclusion

It has been shown that institution of a zero-sum game among a group of firms by means of relative profit maximizing incentives is capable of reducing or eliminating incentives for firms to collude, either actually or tacitly. This mild change in managerial incentives can be imposed at essentially zero public or private cost, yet it reaps potentially huge benefits.³

Appendix A. Optimal Weighting of Goal Functions

This appendix derives the conditions for goal functions needed to achieve a zero-sum game with desirable long-run properties. Suppose there are N ($N \geq 2$) firms in an industry. Let $\pi_1, \pi_2, \dots, \pi_N$ be the profits earned by these firms, and let G_1, G_2, \dots, G_N be the goal functions for these firms. Let w_{ij} be the weight placed on firm j 's profits in firm i 's goal function, and let K_i be an arbitrary constant which adjusts firm i 's goal satisfaction upwards or downwards (e.g., a fixed salary component in managerial pay). Goal functions which are linear in profits have the form:

$$G_i = \sum_{j=1}^N w_{ij}\pi_j + K_i \quad (\text{A.1})$$

for all $i \in [1, N]$, where all w 's and K 's are fixed constants.

The zero-sum conditions require:

$$\sum_{i=1}^N w_{ij} = 0, \quad (\text{A.2})$$

³ One famous estimate of the deadweight cost of monopoly power (including oligopoly) is between 1/2% and 2% of G.N.P. (Scherer and Ross, 1990, p. 667)

Suppose each firm sells a standardized product and that price depends solely on industry output: $P = p(Q)$, where $Q = \sum Q_i$. Assume further (which is likely in the long run) that cost functions are identical for each firm: $TC_i = C(Q_i)$. Hence, $\pi_i = PQ_i - C(Q_i)$, so that we obtain:

$$G_i = \sum_{j=1}^N w_{ij}(PQ_j - C(Q_j)) + K_i \quad (\text{A.3})$$

Define $a_{ji} = \partial Q_j / \partial Q_i$ as any arbitrary conjecture which firm i entertains about the reaction function of firm j ($a_{ii} = 1$). Thus:

$$(\partial G_i / \partial Q_i) = \sum_{j=1}^N a_{ji} w_{ij} [P - C'(Q_j)] + p'(Q) \sum_{j=1}^N w_{ij} Q_j = 0 \quad (\text{A.4})$$

Assuming that N firms in the industry is a given and that marginal cost is increasing, then the optimal industry outcome occurs only when firm outputs are identical ($Q_j = Q/N$) and price equals marginal cost [$P - C'(Q_j) = 0$] for each firm. These conditions are met only when the weights on profits meet the following conditions:

$$\sum_{j=1}^N w_{ij} = 0 \quad (\text{A.5})$$

These N conditions for long-run industry optimality are in addition to the N conditions in (A.2) on weights needed to insure the zero-sum nature of the game. Short-run effects⁴ not analyzed here may perhaps place additional restrictions on the optimal values for weights in the goal functions of firms.

Appendix B. Short-run Cost Differences

This appendix employs a 2-firm game to model the consequences of short-run cost differences between firms. Let $C_1(Q_1)$ and $C_2(Q_2)$ be the cost functions of firms 1 and 2, and let $a_{12} = \partial Q_1 / \partial Q_2$ and $a_{21} = \partial Q_2 / \partial Q_1$ be any arbitrary conjectures which each firm entertains about the reaction functions of the other firm. The problem itself may be stated thus:

$$G_1 = \pi_1 - \pi_2 = p(Q)Q_1 - C_1(Q_1) - p(Q)Q_2 + C_2(Q_2), \quad (\text{B.1})$$

$$G_2 = \pi_2 - \pi_1 = p(Q)Q_2 - C_2(Q_2) - p(Q)Q_1 + C_1(Q_1). \quad (\text{B.2})$$

⁴ These short-run effects include possible incentives for pair-wise or subset collusion, or possible concerns about distribution of output among firms, if short-run costs differ significantly among firms and there are three or more firms in the same zero-sum game.

The first order conditions are:

$$\begin{aligned} \partial G_1 / \partial Q_1 &= p'(Q)(1 + a_{21})(Q_1 - Q_2) + p(Q)(1 - a_{21}) \\ &\quad - C'_1(Q_1) + a_{21}C'_2(Q_2) = 0 \end{aligned} \quad (\text{B.3})$$

$$\begin{aligned} \partial G_2 / \partial Q_2 &= p'(Q)(1 + a_{12})(Q_2 - Q_1) + p(Q)(1 - a_{12}) \\ &\quad - C'_2(Q_2) + a_{12}C'_1(Q_1) = 0 \end{aligned} \quad (\text{B.4})$$

It can be shown that the only solution which satisfies Equations (B.3) and (B.4) has the form:

$$p(Q) = \frac{C'_1(Q_1) + C'_2(Q_2)}{2} \quad (\text{B.5})$$

$$(Q_1 - Q_2) = \frac{C'_1(Q_1) - C'_2(Q_2)}{2p'(Q)} \quad (\text{B.6})$$

Equation (B.5) tells us that price will be set equal to the average of the marginal costs of the two firms. Equation (B.6) tells us that the more efficient firm will produce more output than the less efficient firm, since $p'(Q) < 0$.

Appendix C. Differentiated Products

This appendix models what happens when products are differentiated and firms compete in prices (Bertrand conjectures). Let the demand structure for the two firms be defined in terms of quantities demanded as a function of two prices: $Q_1 = Q_1(P_1, P_2)$ and $Q_2 = Q_2(P_1, P_2)$. It is reasonable to assume $(\partial Q_j / \partial P_j) < 0$ and $(\partial Q_i / \partial P_j) > 0$ for all i and j , $j \neq i$. The problem is stated thus:

$$\begin{aligned} G_1 = \pi_1 - \pi_2 &= Q_1(P_1, P_2)P_1 - C_1(Q_1(P_1, P_2)) \\ &\quad - Q_2(P_1, P_2)P_2 + C_2(Q_2(P_1, P_2)) \end{aligned} \quad (\text{C.1})$$

$$\begin{aligned} G_2 = \pi_2 - \pi_1 &= Q_2(P_1, P_2)P_2 - C_2(Q_2(P_1, P_2)) \\ &\quad - Q_1(P_1, P_2)P_1 + C_1(Q_1(P_1, P_2)) \end{aligned} \quad (\text{C.2})$$

The first-order conditions are:

$$\begin{aligned} (\partial G_1 / \partial P_1) &= Q_1 + P_1(\partial Q_1 / \partial P_1) - C'_1(Q_1)(\partial Q_1 / \partial P_1) \\ &\quad - P_2(\partial Q_2 / \partial P_1) + C'_2(Q_2)(\partial Q_2 / \partial P_1) = 0 \end{aligned} \quad (\text{C.3})$$

$$\begin{aligned} (\partial G_2/\partial P_2) &= Q_2 + P_2(\partial Q_2/\partial P_2) - C'_2(Q_2)(\partial Q_2/\partial P_2) \\ &\quad - P_1(\partial Q_1/\partial P_2) + C'_1(Q_1)(\partial Q_1/\partial P_2) = 0 \end{aligned} \quad (C.4)$$

We may rearrange these conditions as expressing the determinants of price-cost margins:

$$P_1 - C'_1(Q_1) = \frac{-Q_1 + [P_2 - C'_2(Q_2)](\partial Q_2/\partial P_1)}{(\partial Q_1/\partial P_1)} \quad (C.5)$$

$$P_2 - C'_2(Q_2) = \frac{-Q_2 + [P_1 - C'_1(Q_1)](\partial Q_1/\partial P_2)}{(\partial Q_2/\partial P_2)} \quad (C.6)$$

The corresponding conditions for APM firms with Bertrand conjectures are:

$$P_1 - C'_1(Q_1) = \frac{-Q_1}{(\partial Q_1/\partial P_1)} \quad (C.7)$$

$$P_2 - C'_2(Q_2) = \frac{-Q_2}{(\partial Q_2/\partial P_2)} \quad (C.8)$$

Suppose we have a situation where two monopolistically competitive firms satisfy equations (C.7) and (C.8) because both firms are maximizing absolute profits. Assume that both firms have positive price-cost margins. Now suppose that one (or both) of the firms is converted into being a relative profit maximizer. If firm one is so converted, its price-cost margin is reduced, because the difference between the right-hand-side terms in equations (C.5) and (C.7) is negative:

$$\frac{[P_2 - C'_2(Q_2)](\partial Q_2/\partial P_1)}{(\partial Q_1/\partial P_1)} < 0 \quad (C.9)$$

Similarly, if firm 2 is converted to relative profit maximizing (assuming firm 1 maintains a positive price-cost margin), it too will wish to reduce its price-cost margin by expanding output and lowering price. Bertrand competition is absolutely the most competitive behavior which it is reasonable to postulate about APM firms, yet RPM firms compete even harder.

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