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Government enterprise: an instrument for the internal regulation of industry

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INTRODUCTION

This paper examines a normative role for a public firm which competes with privately owned firms in an oligopolistic setting. In spite of the prevalence of this form of public enterprise, with the exception of a paper by Merrill and Schneider (1966) we find virtually no economic analysis of this problem.[1] The analysis focuses on the issue of how a government enterprise could be used to promote static economic efficiency within a non-competitive market structure where policy instruments are limited to the set of variables under the control of the government-owned firm. Because of their strategic interdependence, the actions of the government firm will affect the profits of the private firms, and this is precisely where the public firm has some scope for affecting the performance of the industry. We assume the public firm is *dominant*, in the sense that it can announce its output policy to the private firms, which in turn react to this policy.

Consider first the case of an industry producing a homogeneous product.

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1 We are not concerned with the natural monopoly argument for public enterprise. If there are regions of initially decreasing average cost for some or all of the firms in the industry these are sufficiently small relative to the size of the market to justify having more than one firm in the industry. See Harris (1978a) for an analysis with decreasing costs.

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Assume that if all firms were privately owned the barriers to entry would permit existing firms to earn economic rents by restricting output. In such a situation a government enterprise could be used as an instrument for the internal regulation of the industry. Given its information regarding demand and cost conditions, the government firm computes that level of industry output for which industry marginal cost equals price of output. The government firm announces that it will make up any difference between this target and the private firms' level of output. This 'reaction function' ensures that all private firms face a fixed output price. Each firm's profit-maximizing decision is to set its output level so that its marginal cost equals price. Provided they do so, the government firm will also set output so that its marginal cost equals price. Note that while the government firm determines the optimal level of production for the industry, profit maximization on the part of the private firms determines the optimal distribution of production across firms.[2]

A government firm could also be used to regulate an industry characterized by a small number of firms producing products which are close substitutes or complements. The above result holds in this monopolistically competitive situation but in a weaker sense. If the government firm can shift each private firm's demand function through changes in the price of its product, a reaction function exists which will enforce the desired allocation of output across firms. In effect the government firm threatens each firm with retaliation in the form of increased or decreased output.

The analysis of this paper is cast in a long-run equilibrium framework. In the short run capacity limitations and costs of adjusting capital stock may prevent the public firm from providing the output necessary to keep price in the short run at the desired level. An explicit dynamic analysis of this problem is provided elsewhere (see Harris and Wiens, 1979).

A formal analysis in a partial equilibrium and static setting is presented in the second section. The operation of a public firm in the absence of complete information is discussed briefly in a third section, while a fourth section compares this form of intervention with some other policy alternatives such as antitrust and price-quantity regulation.

AN ANALYSIS OF THE DOMINANT PUBLIC FIRM

Homogeneous product

Consider an oligopolistic industry where all firms produce the same homogenous good. The industry consists of $n + 1$ firms indexed $i = 0, 1, \ldots, n$, with cost functions $C_i(q_i)$ which are convex, increasing with respect to output q_i, and twice continuously differentiable. The inverse demand function for the industry is given by $D(Q)$, where demand is downward-sloping and $Q =$

2 If the government firm is created by purchasing an existing oligopolist at its market price, the capitalized rents will be offset by the increase in consumer surplus.

$\sum_{i=0}^{n} q_i$. Denote the government firm by the index $i = 0$. Assume it wants to maximize social welfare given by the conventional surplus measure

$$W(q_0, q_1, ..., q_n) = \int_0^Q D(\tau)d\tau - \sum_{i=0}^{n} C_i(q_i), \tag{1}$$

i.e. consumer surplus plus producer surplus. The private firms want to maximize profits given by $\pi_i(q_0, q_1, ..., q_n) = q_i D(Q) - C_i(q_i)$, $i = 0, ..., n$. Call an allocation $q^* = (q_0^*, q_1^*, ..., q_n^*)$ optimal if and only if it maximizes (1) and therefore if and only if it satisfies price equal marginal cost, $D(Q^*) = C_i'(q_i^*)$, for all firms $i = 0, 1, ..., n$, where $Q^* = \sum_{i=1}^{n} q_i^*$.

Suppose the government firm announces its output policy as a function, $q_0 = \phi(q_1, ..., q_n)$. The profit of the ith private firm, given the reaction function ϕ, is $\pi_{i\phi}(q_1, ..., q_n) \equiv \pi_i[\phi(q_1, ..., q_n), q_1, ..., q_n)]$. Once the reaction function ϕ has been announced to the private firms, they are faced with an oligopolistic situation with interdependencies among firms occurring through the joint effect of the market demand function and the government firm's reaction function. For each reaction function ϕ there will be a different non-co-operative game played by the private firms. Let $\bar{q}_i = (q_1, ..., q_{i-1}, q_{i+1}, ..., q_n)$, i.e. the ith component deleted from the vector $\hat{q} = (q_1, ..., q_n)$.

Suppose there exists a reaction function ϕ^* such that

$$\pi_{i\phi^*}(q_i^*, \bar{q}_i) \geqslant \pi_{i\phi^*}(q_1, ..., q_n), \tag{A}$$

for all $\bar{q}_i, \hat{q}$;

$$q_0^* = \phi^*(q_1^*, ..., q_n^*). \tag{B}$$

Property (A) requires that against the reaction function ϕ^*, q_i^* is the dominant strategy choice for the ith firm, i.e. the ith firm will choose q_i^* independently of what other firms do. Property (B) requires that the reaction function be consistent with an optimal decision by the government firm. If such a reaction function exists we say that the reaction function ϕ^* 'strongly supports' the allocation q^*. It will now be shown that for the case of an oligopoly producing a homogeneous product such a reaction function exists.

Consider the reaction function

$$q_0 = Q^* - \sum_{i=1}^{n} q_i. \tag{2}$$

Then $\pi_{i\phi}(q_1, ..., q_n) = D(Q^*)q_i - C_i(q_i)$, and each private firm will choose its output $q_i = q_i^*$ so that price equals marginal cost, $C_i'(q_i) = D(Q^*)$, provided profits at this price and output level are non-negative. Furthermore, since the private firms choose q_i^*, the output level for the government firm will be q_0^*. Thus the reaction function (2) strongly supports the allocation q^*.

Differentiated products

Now consider a market structure characterized by a small number of firms producing products which are close substitutes or complements. The twice continuously differentiable inverse demand function for each firm i is denoted by $D^i(q_0, q_1, \ldots, q_n)$. The government firm's output is assumed to affect the location of the private firms' demand schedules, thus $D_0{}^i$ and $D_{00}{}^i$ are taken to be uniformly bounded away from zero, where $D_0{}^i$ denotes $\partial D^i/\partial q_0$, $D_{00}{}^i$ denotes $\partial^2 D^i/\partial q_0{}^2$, and so on. We also require that the marginal effect of the government firm's output on private firms' price is diminishing, $D_{00}{}^i < 0$. Call an allocation q^* optimal if and only if $C_i'(q_i^*) = D^i(q_0^*, \ldots, q_n^*)$ for all i. Assume that at least one optimal allocation exists with $q_i^* > 0$ for all i.

Given a reaction function ϕ chosen by the government firm, which gives the output of the government firm as a function of the outputs of all other firms, the n private firms face on oligopolistic situation. Each private firm's profit function is given by $\pi_{i\phi}(q_1, \ldots, q_n) \equiv q_i D^i[\phi(\hat{q}), \hat{q}] - C_i(q_i)$. We treat the oligopoly game as a traditional non-co-operative game with perfect information. A Cournot-Nash equilibrium is defined as an n-tuple $(q_1', \ldots, q_n')$ of outputs such that

$$\pi_{i\phi}(q_i', \bar{q}_i') \geqslant \pi_{i\phi}(q_i, \bar{q}_i'),$$

for all $q_i \geqslant 0$, all $i = 1, \ldots, n$.

A reaction function ϕ^* is said to 'weakly support' the allocation q^* if and only if

q^* is a Cournot-Nash equilibrium relative to the profit functions $\pi_{i\phi^*}$; (C)

$$q_0^* = \phi^*(q_1^*, \ldots, q_n^*). \tag{D}$$

We say that the reaction function weakly supports q^* because it does not have the dominant strategy property characteristic of strongly supporting reaction functions. Property (C) implies that firm i will choose q_i^*, given the reaction function ϕ^* and output levels $\bar{q}_i^*$ for all other firms. Property (D) requires that the reaction function induce an optimal output decision by the government firm, given that all other firms produce at optimal levels.

To demonstrate the existence of a weakly supporting reaction function to any optimal allocation q^* we proceed again by construction. Consider the reaction function ϕ^*, given by

$$\phi^*(q_1, \ldots, q_n) = \alpha + \sum_{i=1}^{n} [\beta_i q_i + \gamma_i (q_i \ln (q_i/q_i^*) - q_i)], \tag{3}$$

where

$$\beta_i = -\frac{\partial D_i}{\partial q_i}(q_0^*, \ldots, q_n^*) \bigg/ \frac{\partial D_i}{\partial q_0}(q_0^*, \ldots, q_n^*),$$

α is a constant chosen such that $q_0^* = \alpha + \sum_{i=1}^{n} \beta_i q_i^*$, and the γ_i are constants defined below.

The β_i are all well defined, given the assumptions on the demand functions.

The first-order conditions to the private firms' maximization problem are

$$\frac{\partial \pi_{i\phi^*}(q_i, \bar{q}_i)}{\partial q_i} = D^i + q_i D_0{}^i \frac{\partial \phi^*}{\partial q_i} + q_i D_i{}^i - C_i{}' = 0 \tag{4}$$

at q^*, given the reaction function (3). The basic idea here is that the β_i are chosen so that at q^* a marginal change in output by private firm i induces a change in the public firm's output, such that the marginal benefit to i of such a move is equal to price minus marginal cost. To establish that all firms are at a profit maximum we must establish that the second-order conditions are satisfied, that is,

$$\partial^2 \pi_{i\phi^*}/\partial q_i{}^2 = 2D_i{}^i + 2D_0{}^i \frac{\partial \phi^*}{\partial q_i} + q_i D_{ii}{}^i + q_i D_{00}{}^i \left(\frac{\partial \phi^*}{\partial q_i}\right)^2 + 2q_i D_{i0}{}^i + q_i D_0{}^i \frac{\partial^2 \phi^*}{\partial q_i{}^2} - C_i{}'' < 0. \tag{5}$$

Since $\partial \phi^* / \partial q_i = \beta_i + \gamma_i \ln (q_i / q_i{}^*)$, (5) can be written as a sum of terms including the expression

$$\gamma_i D_0{}^i + \gamma_i \ln (q_i/q_i{}^*)[D_0{}^i + 2q_i(\beta_i D_{ii}{}^i + D_{0i}{}^i)] + \gamma_i{}^2 q_i (\ln (q_i/q_i{}^*))^2 D_{00}{}^i. \tag{6}$$

By assumption, all first and second partial derivatives of the inverse demand functions are uniformly bounded, $D_0{}^i$ and $D_{00}{}^i$ are uniformly bounded from zero, and $D_{00}{}^i > 0$. If we choose $|\gamma_i|$ large enough, with sign γ_i equal to minus sign $D_0{}^i$, the term (5) can be made negative everywhere on any compact subset Ω of the interior of $R_+{}^{n+1}$. Thus $\pi_{i\phi^*}(q_i, \bar{q}_i)$ is a strictly concave function in q_i on Ω, implying that (4) is both necessary and sufficient to describe the firms' optimal output choices.

We conclude, therefore, that q^* can be sustained as a Cournot-Nash equilibrium by the government firm's using the reaction function (3). Unless the demand functions exhibit some special separability properties, the private firms' choices do not have the dominant strategy property, and hence the reaction function (3) weakly supports the allocation q^*. Note that this allocation is not stable against coalition formation by private firms.

AN ITERATIVE SCHEME WITH INCOMPLETE INFORMATION

In this section we examine the dominant public firm scheme in the homogeneous product case when the government-owned firm has only limited information about the cost functions of the other firms. The analytical approach we take is the analysis of an idealized iterative scheme, with the government firm revising its policy at each iteration in response to what it observes. This approach, which is common in the planning literature, has its shortcomings, but it does have the merit of approximating a real world regulatory process which proceeds by trial and error. In the real world, of course, the number of actual iterations are very few. Any firm in the industry, including the government firm, is assumed to know only the market demand function, the government firm's reaction function, and its own cost function. No firm has any information about other firms' cost functions.

The iterative scheme in discrete time is as follows. The government firm announces to private firms a reaction function, $q_0{}^t = Q^t = \sum_{i=1}^{n} q_i{}^t$, where Q^t is a parameter which is the target aggregate output in the tth iteration. During iteration t, following the previous analysis, equilibrium occurs with private firms all producing $q_i{}^t$, where $C_i'(q_i{}^t) = D(Q^t)$, for $i = 1, \ldots, n$, and the government firm produces $q_0{}^t = Q^t - \sum_{i=1}^{n} q_i{}^t$. After equilibrium has occurred, the government firm revises the reaction function parameter Q^t, aggregate industry output, according to the following rule: it increases (decreases) Q^{t+1} if it observes that its marginal cost is less than (greater than) the industry price, and the process repeats itself. If its marginal cost equals industry price, no change occurs in the reaction function parameter, and the entire process stops.

This procedure has some interesting properties. First, at no point is information transmitted direct from the private firms to the public firm or between the private firms. The public firm only acquires indirect information about private firms, in that at each iteration it knows what they as a group are producing by observing $Q^t - q_0{}^t$. At each iteration the market clears at Q^t, the government firm making up the difference between private firms' output and the planned aggregate output Q^t.

In continuous time the government firm's revision rule can be expressed as $\dot{Q} = \lambda[D(Q) - C_0'(q_0)]$, where $\lambda > 0$ is a speed of adjustment parameter and $\dot{x} \equiv dx/dt$. From the private firms' optimality conditions we can write each q_i as a function of Q, and thus the reaction function can be written as $q_0 = Q - \sum_{i=1}^{n} q_i(Q)$. Using this and substituting into the revision rule gives an ordinary differential equation in the single variable Q. Differentiating the welfare function with respect to t, substituting $C_i'[q_i(Q)] = D(Q)$ for $i = 1, \ldots, n$, and noting that $\sum_{i=1}^{n} q_i'(Q) = 1 - q_0'(Q)$, we get

$$\dot{W} = [D(Q) - C_0'(q_0)]\dot{Q}q_0'(Q) = \frac{1}{\lambda}(\dot{Q})^2 q_0'(Q). \tag{7}$$

Since $q_0'(Q) > 0$, (7) gives $\dot{W} > 0$ if $P \neq C_0'$ and $\dot{W} = 0$ if $P = C_0'$. Thus, provided the process has not terminated, social welfare monotonically increases with each iteration and, given a sufficient number of iterations, will converge arbitrarily close to a global optimum.

As with any resource allocation mechanism, if all firms understand how the mechanism functions, it suffers from certain incentive problems. The private firms want to see aggregate output lower, and consequently price higher, than does the government firm. If they understand how the government firm revises its aggregate output target, they have an incentive at each iteration to produce less than they otherwise would, i.e. operate where price exceeds marginal cost. This makes the government firm produce more and raises its marginal cost, and then through the adjustment mechanism lowers industry output and raises the price. How serious this incentive problem is will depend upon the degree of sophistication of the private agents, how farsighted they are, and how well they understand the process the government firm is using.

COMPARISON WITH ALTERNATIVE POLICIES

The main policy proposals to deal with the market power of oligopolies are nationalization of the industry, antitrust policy, and direct regulation. Complete nationalization is excluded a priori as politically or economically not feasible.

Antitrust policy may be ineffective in the case of oligopoly because it is impossible to legislate against strategic behaviour of a non-collusive nature. Antitrust is best suited to dealing with collusive and non-competitive practices within an industry. Whether public enterprise has any role to play in this regard is an open question.[3]

What of direct regulation of prices and/or quantities within the industry? If a regulatory agency fixes the price in the industry, the inefficiencies due to the strategic interaction of private firms are eliminated. Precisely the same outcome can be achieved through the use of a dominant government firm in the industry in a world of complete and perfect information.

But suppose information is imperfect. One advantage of the government firm is that it knows its own technology and hence costs, and to the extent that other firms in the industry have similar costs the government firm has partial information on these as well. The regulatory agency does not have direct information of this type and must either rely on the information provided to it by the private firms, which may be distorted, or expend resources in acquiring this information.

One of the major difficulties with price regulation is that because of either imperfect information or administrative lags the price is not set at the market-clearing value. It then becomes necessary either to ration the available supply or demand or to have the government run a buffer stock scheme. A government firm using the reaction function mode avoids this problem. While it may face the same informational difficulties as the price regulator in estimating the appropriate level of aggregate industry output, it can always adjust its output so that the market clears. In this case the social cost incurred is an efficiency loss, because the government firm will not be producing where its marginal cost equals price; all private firms, however, will produce at levels such that price equals marginal cost (see Harris, 1978b).

3 Wiens (1978a) compares a dominant-government-firm procedure with antitrust policy and vertical diverstiture in the context of public intervention in a vertically integrated industry. Government firm regulation is found to be superior because it does not place constraints on the organizational form chosen by the private firms. Market power and rents which may result from increased concentration are offset by direct competition from the government firm.

CONCLUSIONS

This paper has considered how a dominant government firm competing with private firms in an oligopolistic industry can improve the allocation of resources within the industry. The normative and positive issues have only begun to be explored. In order to evaluate dominant public firms in relation to alternative regulation schemes it is critical to pay attention to problems such as informational asymmetries and bureaucratic incentives[4] which plague regulatory schemes in the real world.

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4 The paper does not tackle the problem of how to get the managers of the public firm to behave in the appropriate manner. Wiens (1978b) has modelled the self-interest interactions of consumers of the industry's product, private producers, politicians, and managers of the government firm. He presents an incentive structure which will cause the government firm managers to behave as efficient regulators. There is some literature on how the managers of public enterprise behave, although not specifically in the context of a public enterprise competing with private firms. For references see Wiens (1978b).

Retention of first-year economic principles

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In two earlier papers (Crowley and Wilton, 1974a and b) we described an educational experiment which commenced at Queen's University in 1970. The objective of the first phase of the experiment was to identify and quantify the factors accounting for student performance in the introductory economics

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