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Public Enterprise Strategies in a Market Open to Domestic and International Competition

Mehrdad SEPAHVAND*

ABSTRACT. – The emerging literature on interaction between strategic trade theory and mixed oligopoly uses a simple example to argue that if the domestic market is open to foreign competition and the government uses a production subsidy then it is socially preferable to privatise the domestic public enterprise even if it is just as efficient as its private counterparts.

This study evaluates the robustness of this result by extending it to a general framework. Furthermore, it argues that allocative efficiency gains attributed to privatisation may also be explained by giving the public enterprise a first mover advantage (as a Stackelberg leader). Thus it suggests it is the timing of the game rather than the ownership structure which is responsible for the inefficiency associated with the presence of a public enterprise in a market open to international competition.

Stratégies des entreprises publiques dans un marché ouvert à la concurrence nationale et internationale

RÉSUMÉ. – La littérature qui se développe sur l'interaction entre la théorie « stratégique » du commerce et l'oligopole mixte utilise un exemple simple pour prouver que si le marché domestique est ouvert à la concurrence étrangère et si le gouvernement utilise des subventions à la production, alors il est socialement préférable de privatiser l'entreprise domestique publique même si elle est aussi efficace que son équivalent privé. Nous évaluons la robustesse de ce résultat en l'analysant dans un cadre général. Nous avançons que les gains d'efficacité allocative attribués à la privatisation peuvent aussi être obtenus en donnant à l'entreprise publique un avantage de premier joueur (en tant que meneur de Stackelberg). Ainsi nous suggérons que c'est le déroulement du jeu plutôt que la structure de la propriété qui est responsable de l'inefficacité associée à la présence d'une entreprise publique dans un marché ouvert à la concurrence internationale.

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Leeds University Business School, Leeds, LS2 93T.

1 Introduction

In recent decades, many countries around the world have been involved in privatisation while at the same time they have used commercial policy to regulate the market. The effects of privatisation and commercial policy instruments on an imperfect market have been analysed by the mixed oligopoly literature and strategic industrial and trade theory separately. Based on the mixed oligopoly literature, the presence of a public enterprise as a direct regulatory device can improve welfare if the market is not competitive enough (DE FRAJA and DELBONO [1989], CREMER *et. al.* [1989]). The existing literature on strategic industrial and trade theory asserts that in an imperfect market, when firms choose outputs which are strategic substitutes, the government of the domestic country can improve welfare by using a subsidy to shrink the wedge between the marginal cost and price in the domestic market and shift the industry profit to the advantage of the domestic firms (EATON and GROSSMAN [1986]). While the operation of a public enterprise and production subsidy can improve welfare separately in an imperfectly competitive market, the effect of a combination of these devices is ambiguous.

The first attempt to explore the connection between privatisation and strategic industrial policy was made by WHITE [1996]. He used a regulated mixed oligopoly model for a closed economy with a linear inverse demand function and an identical quadratic cost function across the firms. He constructed a two stage game in which at the first stage the government uses an output subsidy. Then at the second stage, firms choose their outputs simultaneously. He found that privatisation does not change the optimal subsidy and welfare levels. The reason simply is that in equilibrium all firms adopt the marginal cost pricing condition. Thus the question about the firm's ownership is irrelevant. MYLES [2002] shows that the irrelevance result suggested by WHITE [1996] holds for more general forms of demand and cost functions. Furthermore, it does not depend on the order of firms' moves.

While the irrelevance result for a regulated market survives several generalisations, PAL and WHITE [1998] present an example to show how the introduction of a foreign firm to the model can lead to its violation. They extend the model of WHITE [1996] to an international context and show that, if the domestic market is open to foreign competition and all firms move at the same time, privatisation always increases domestic welfare and it decreases the level of optimal subsidy which is required to regulate the market. This result provides a strong argument in favour of privatisation because it claims that, even if the public firm is just as efficient as the private firms, welfare may still be enhanced by privatising it.

In this study we extend the basic model of PAL and WHITE [1998] from the linear-quadratic case to accommodate more general forms of demand and cost functions. In this fairly general framework, we argue that the welfare improvement of privatisation in a regulated market open to foreign competition can be explained by the order of moves. Assuming that the public authority uses an output subsidy and the operation of the public sector as two alternative regulatory devices at the same time, we will show that anything a regulated privatised industry can achieve can always be mimicked by instructing the public firm to follow an appropriate policy in a regulated mixed market structure. Although an appropriate policy for the public firm in the presence of a foreign firm is not following the marginal cost pricing condition (FJELL and PAL [1996]), we show that there still exists a pricing condition resulted from the equilibrium behaviour of the public enterprise which can ensure the maximum attainable welfare for the domestic economy. To allow the public firm to follow this pricing condition, the interaction of firms needs to be modelled by using a sequential game.

From the theoretical point of view both PAL [1998] and CORNES and SEPAHVAND [2003] argue that sequential play is a more plausible assumption about the firms' moves in a mixed oligopoly. They show that if firms have some flexibility in their timing of actions, the simultaneous play does not lead to a self-enforcing equilibrium in a mixed oligopoly model. This raises doubt about the credibility of firms' commitments to the simultaneous strategy in PAL and WHITE's model. In this study we adopt an alternative assumption, namely STACKELBERG public firm leadership, that is also inspired by the fact that industries with mixed market structure are typically dominated by former public monopolists.

We consider three regimes. These regimes differ only in the way that the domestic firms are regulated. In all these regimes, the public authority uses the operation of the public sector and/or an optimal subsidy in advance of the private firms' moves. In the first regime, all domestic firms are publicly owned and a board of public managers regulates the home industry. In the second regime, private firms and a public firm are competing in the domestic market where the behaviour of the domestic private firms is regulated by an output subsidy. In the third regime, a regulated privatised industry regime, all firms in the home industry are profit-maximising private firms and the government sets an optimal subsidy in advance of firms' moves. Our comparison shows that the welfare improving effect of privatisation depends on the public firm's action.

The paper starts with the case of a closed economy. We show that the irrelevance result for a closed economy is contingent upon the government evaluation of the distribution of total surplus between consumers and producers. Throughout the second part of the paper we hold the assumption of a benevolent government which seeks to maximise social welfare as unweighted sum of the consumers' and producers' surpluses and extend the irrelevance result to a market open to international competition.

This paper is organised as follows. Section 2 introduces a general framework as a triopoly model. Then, Section 3 establishes the irrelevance result for a closed economy based on the MCP condition and shows its limitations. Section 4 extends the model to an international context, introduces the adjusted marginal cost pricing condition which is the optimal pricing condition of the domestic economy in the presence of international competition and analyses the equilibrium behaviour of firms in different regimes. Section 5 concludes.

2 The Basic Framework

Consider a country with a domestic market for a homogeneous good produced by 2 domestic firms and one foreign firm. If the home industry output is denoted by Q^h, then the total output is $Q = Q^h + q_f$ where q_f denotes the output of the foreign firm.

It is assumed throughout that:

ASSUMPTION 1: *The inverse demand $p(Q)$ is a finite-valued, twice continuously differentiable and strictly log-concave function with $p'(Q) < 0$.*

ASSUMPTION 2: *There exists $\bar{Q} < \infty$ where $p(\bar{Q}) = 0$ and $p(Q) > 0$ for all $Q \in [0, \bar{Q})$.*

ASSUMPTION 3: *All firms have an identical, single-valued, twice continuously differentiable and strictly convex cost function with $c'(q) > 0$ and $c''(q) > 0$ for all $q \geqslant 0$ and $c(0) = 0$.*

The strict log-concavity of the inverse demand function is a weaker assumption than concavity. It asserts that $p(.)$ satisfies $p'(Q) + Qp''(Q) < 0$ for all $Q \in [0, \bar{Q})$. The strict convexity assumption imposed on the cost function is quite common in mixed oligopoly models. Otherwise, the public firms with the same cost structure as private firms supplies the whole market alone, leaving no room for the coexistence of the public enterprise and private firms.

We assume the government of the domestic country regulates the market by using a subsidy s per unit of the production of the domestic private firm, q_m. Thus the domestic private firm's profit function is

$$\pi_m = p(Q)q_m - c(q_m) + sq_m \tag{1}$$

and the profit of the foreign firm is

$$\pi_f = p(Q)q_f - c(q_f). \tag{2}$$

The domestic government maximises the weighted sum of the consumer and producers' surplus. Let α denotes the trade-off between the consumers' and producers' surpluses in the government objective function. Then any unit transfer from the consumer to the producers causes $(1 - \alpha)$ loss (gain) when α is smaller (greater) than one. The objective function of the government can be written as,

$$W = \alpha(\pi_n + \pi_m) + CS - \lambda T \tag{3}$$

where $\pi_n = p(Q)q_n - c(q_n)$ is the public firm's profit, T is a transfer from the consumers to producers and $\lambda = (1 - \alpha)$ captures the cost or gain of the transfer. If $\alpha = 1$ the government values the consumers' and producers' surpluses equally. As consumers are typically large in numbers, $\alpha < 1$ may indicate that the government seeks to maximise its votes. One may argue that $\alpha > 1$ because producers are more capable of creating organised interest groups in order to influence the government policy stance. We consider these possibilities by assuming $\alpha \in (0,2]$. However when we deal with the comparison of two policy devices mentioned above, we mainly rely on the assumption that $\alpha = 1$ because otherwise, as we show in Section 3, these alternative policy instruments are not comparable.

We assume firms choose their output levels as strategic choice variables and are involved in a quantity-setting game. The set of the domestic firm's strategies is $S_h = [0, \bar{Q}]$ and the foreign firm's strategy set S_f is a closed subset of real numbers.

We take the total number of the firms as exogenously given. A two stage game is applied to model the interaction of firms in different settings. Three regimes are considered. These are *i)* a state-owned industry where the home industry is publicly owned to maximise social welfare and acts as a STACKELBERG leader where the foreign firm follows its decision, *ii)* a regulated privatised industry in which all domestic firms are privatised and regulated by a production subsidy, and *iii)* a regulated mixed market structure where the operation of the public firm and a subsidy to the private firm's production are used in advance of the private firms' moves to regulate the market. In the latter setting we also consider the effects of change in the order of firms' moves by allowing the public enterprise to adopt a simultaneous play strategy. In all regimes, the public authority uses a subsidy to the domestic private firms' output and/or the operation of the public sector in advance of the private firms' moves. We seek the subgame perfect Nash equilibrium outputs of firms in pure strategies. In all cases, using backward induction, first we solve the model for the second stage equilibrium expressions. Since all objective functions are smooth (twice differentiable) and strictly concave in their own strategy variables, the equilibrium expressions are obtained from the solution of a system of the first order conditions of the profit maximisation problems $\frac{\partial \pi}{\partial q} = 0$ for private firms operating in the second stage of the game. Then, given the outcomes of the last stage as a function of the subsidy and/or the output of the public sector, we look for the SPNE level of s and q_n.

3 The Case of a Closed Economy

3.1 A State-Owned Industry

Consider first a closed economy with 2 domestic public firms in the market where there is no foreign competitor. Following the literature of mixed oligopoly we abstract from principal-agent problem to concentrate on the difference between public and private firms' objectives. Thus we may assume that the state-owned industry produces efficiently an output level that serves the government's objective. For a given Q, efficiency in production requires solving the following problem,

$$\text{(4)} \qquad \underset{q_1,q_2\in S_h}{\text{Min}} \; c(q_1)+c(q_2) \; s.t. \; q_1+q_2=Q.$$

Assuming that there is a cost function $C(Q)=Min\{c(q_1)+c(q_2)\,|q_1+q_2=Q\}$ along which the allocation of production of any output level among the domestic firms is cost minimising, a total output level that maximises the board objective function (3) solves the following problem,

$$\text{(5)} \qquad \underset{Q\in S_h}{\text{Max}} \; W=\int_0^Q p(t)dt-\alpha C(Q)-(1-\alpha)R(Q).$$

where $R(Q)=p(Q)Q$ is the total industry revenue. The solution of this setting yields price as a weighted sum of marginal cost $C'(Q)$ and marginal revenue of the industry $R'(Q)$,

$$\text{(6)} \qquad p(Q^*)=\alpha C'(Q^*)+(1-\alpha)R'(Q^*).$$

Considering that at equilibrium firms produce equally, we have $C'(Q^*)=c'(q_n^*)$ and the solution vector (Q^*,q_n^*) should satisfy the following conditions:

$$\text{(7)} \qquad \begin{cases} i)\; p\left(Q^*\right)=c'(q_n^*)+\left(\dfrac{1-\alpha}{\alpha}\right)p'\left(Q^*\right)Q^* \quad n=1,2 \\ ii)\; Q^*=2q_n^* \end{cases}.$$

The price in the state-owned industry setting varies from lowest possible price $(p(\bar{Q})=0)$ to the equilibrium price level of a COURNOT duopoly depending on the value of α. As α tends to zero, the public industry's output approaches the maximum output $\bar{Q}$ and price becomes close to zero. If $\alpha=1,$ firms produce where price equals MC. For any $\alpha>1$ firms deviate from MCP condition towards COURNOT equilibrium price.

3.2 A Regulated Privatised Industry

In a regulated privatised industry, the game consists of two stages. At stage 1, government chooses the level of subsidy to maximise welfare. Then at stage 2, firms choose their outputs simultaneously to maximise their profits under the COURNOT assumptions.[1]

1. Concerning the existence of a solution for this stage, for $\alpha=1,$ identical cost structure and convex technology assumptions together are sufficient to guarantee the existence of a unique Cournot equilibrium. If $\alpha>1,$ the addition of the assumption of log-concavity of demand function provides a sufficient condition for the existence of a unique COURNOT solution. If $\alpha<1$, however, we need to add an extra restriction $\left(\dfrac{p''Q+p'}{\alpha\,(p''Q+2p'-c'')}<1\right)$ to avoid the non-existence problem.

Let $q_m(s)$ be the $m'th$ private firm's equilibrium output at the second stage of the game. As firms are symmetric in the sense that they have the same cost structure the equilibrium output of the industry $Q(s) = 2q_m(s)$. At the first stage, the government anticipates the firms' equilibrium outputs as functions of subsidy and chooses s^* to maximise (3). The solution of the government's problem satisfies the equilibrium condition (6). However here the marginal revenue of the industry is $R' = \partial([p(Q)+s]Q)/\partial Q$. Considering the equilibrium condition of the second stage, we may conclude that (q_m^*, Q^*, s^*) is the equilibrium solution of the game if it satisfies the following conditions (see Appendix A)

$$(8)\quad \begin{cases} i)\ p\left(Q^*\right) = c'\left(q_m^*\right) + \left(\dfrac{1-\alpha}{\alpha}\right)\left[p'\left(Q^*\right)Q^* + s^*\left(1/\varepsilon_{Qs}+1\right)\right] \\ ii)\ s^* = -\dfrac{(2-\alpha)}{1+(1-\alpha)/\varepsilon_{Qs}}\,p'\left(Q^*\right)q_m^* \\ iii)\ Q^* = 2q_m^* \end{cases}$$

where ε_{Qs} is the elasticity of the industry supply with respect to the subsidy. Given the level of subsidy, since the first term in square bracket is always non-positive, for any $\alpha < 1$ ($\alpha > 1$), it shifts price down (up) below (above) marginal cost. But the level of subsidy and ε_{Qs} are always non-negative. It follows that the second component in the square bracket in both cases reduces the effects of the first component and adjusts the price close to MC. Thus (8) deviates less than (7) from the MCP condition. The intuition behind this result is as follows when $\alpha \neq 1$. If $\alpha < 1$, the government sets the price lower than marginal cost because it values the consumer's welfare more than the producers. However, the government cannot use the subsidy as it wishes because the subsidy is a costly policy instrument compared with the operation of a public firm. A comparison of (7) and (8) when $\alpha = 1$ implies the following result.

LEMMA 1: *If the government values the consumers and producers' surpluses equally, in both regulated privatised and state-owned industry regimes firms produce where their marginal costs equal the market price.*

From (8*i*) the optimal subsidy to the private firm's production is $s^* = -[p'(Q^*)]q_m^*$. As the literature on strategic industrial policy asserts, the optimal subsidy in an imperfect competitive market is always positive because $p' < 0$. The equilibrium level of firms' outputs in state and private industry regimes are the same if the value of producers' surplus in the government's objective function is sufficiently high. If $\alpha = 2$, the optimal subsidy is equal to zero and the government stays out of the market and, the unregulated private industry yields the same result as a state-owned industry regime. One may argue that in a COURNOT competition firms effectively maximise a weighted sum of social welfare and their total profits (WOLFSTETTER [1999]). Thus it is not surprising if at some point the unregulated behaviour of firms under COURNOT competition serves the government's objective with unequal weights for the industry profit and consumers' surplus.

3.3 A Mixed Market Structure

In a regulated mixed structure regime, firms' interaction can be modelled by both simultaneous and sequential game. In a public Stackelberg leadership game both regulatory devices are used at the same time. At the first stage, the government sets the level of optimal subsidy while the public firm chooses the level of output to maximise (3), taking the reaction of the private firm into account. At the second stage of the game, the private firm chooses its output for any given level of subsidy and the output of the public firm. Alternatively, the public firm may move simultaneously with private firms at the second stage of the game while the government sets price in advance of firm's moves.

An interesting case is where $\alpha = 1$. Under this assumption the only difference between the state-owned and private firms' behaviour is because of their objectives. However as both types of firms at equilibrium produce where their marginal cost is equal to the market price we may claim the following result.

PROPOSITION 1: *If the government values the consumers' and producers' surpluses equally, the equilibrium levels of the optimal subsidy and welfare are identical for a closed economy irrespective of whether i) there is a public firm which competes with a private firm under* COURNOT *assumptions, ii) the public firm acts as a Stackelberg leader where the private firm follows its decision or, iii) the industry is privatised and regulated by an optimal subsidy.*

PROOF: (see Appendix B for the proof).

This result corresponds to MYLES [2002] though his model is built upon different assumptions.

Is the irrelevance result mentioned above sensitive to the government's distributional objectives? To answer this question we need to consider the equilibrium behaviour of firms in a general case where $\alpha \neq 1$. Suppose that firms are involved in a public firm leadership game in a mixed market structure. It can be checked by the same procedure as (8) that the solution vector (q_n^*, q_m^*, s^*) satisfies the following conditions

(9)
$$\begin{cases} i)\ p(Q^*) = c'(q_m^*) + \left(\dfrac{1-\alpha}{\alpha}\right)\left[p'(Q^*)Q^* + s^*\left(1/\varepsilon_{q_m s} + 1\right)\right] \\ ii)\ p(Q^*) = c'\left(q_n^*\right) + \left(\dfrac{1-\alpha}{\alpha}\right)\left[p'\left(Q^*\right)Q^* + s^*/\varepsilon_{q_m s}\left(\partial q_n/\partial q_m\right)\right] \\ iii)\ s^* = -\dfrac{1}{\alpha + (1-\alpha)/\varepsilon_{q_m s}}[p'(Q^*)q_m^* + (1-\alpha)p'(Q^*)q_n^*] \\ iv)\ Q^* = q_m^* + q_n^* \end{cases}.$$

where $\varepsilon_{q_m s}$ is the elasticity of the private firm's supply with respect to the subsidy. Obviously, the irrelevance result does not hold any more if the government values the consumers' and producers' surpluses unequally. With $\alpha \neq 1$, adopting different patterns of pricing at equilibrium leads to unequal distribution of the total production between the firms with the same cost structure. This violates the productive efficiency condition.

4 Privatisation in a Market Open to Foreign Competition

In this section we extend the model to international competition and assume that the government values the consumers' and producers' surpluses equally.[2] In the presence of a foreign competitor, as FJELL and PAL [1996] have noticed, the public sector does not follow the MCP condition. The domestic economy produces Q^h, but it consumes $Q = Q^h + q_f$ which partly is provided from abroad *via* imports.

Let V be the set of all points which characterise the best response of the foreign firm for any given output level of the home industry. We assume the welfare of the domestic country can be ranked along the best response function of the foreign firm and,

ASSUMPTION 4: *There exist s a unique point,* $(Q^{h*}, q_f^*) \in V \equiv \{(Q^h, q_f) \in R^2, q_f \in arg\max \pi_f(Q^h, q_f), Q^h \in A_n\}$ *which maximises the welfare function of the domestic economy.*

Assumption 4 guarantees the existence of the most preferred combination of outputs along the best response of the foreign firm that maximises social welfare of the domestic country.[3]

The slope of the foreign firm's best response under assumptions (1-3) reveals some important properties.

2. This assumption allows us to focus on the equilibrium behaviour of the domestic firms when the objective of the regulatory policy under different market structures is the same. The results of the previous section indicates that this is possible only if $\alpha = 1$. With this assumption our results also will be comparable with the outcomes of the other works in this literature.
3. We take the existence of the equilibrium as given to focus on the purpose of this study that is a comparison of equilibria under different regimes. However one could establish the existence result by imposing some extra restrictions on the curvatures of the functions. For instance, the sufficient condition for the existence of a existing a unique optimum can be derived from $p''(1+b')^2 + b''p' \geqslant 0$ where $b' = \frac{\partial q_f}{\partial Q^h}$ and $b'' = \frac{\partial^2 q_f}{\partial Q^{h2}}$. This guarantees the strict concavity of $W(Q^h, q_f(Q^h))$.

LEMMA 2: *The slope of the best response function of the foreign firm is decreasing and belongs to the interval* (–1,0).

PROOF: *Using the rule of implicit differentiation the slope of the foreign firms best response function is*

(10) $$\frac{dq_f}{dQ^h} = -\frac{p''(Q)q_f + p'(Q)}{p''(Q)q_f + p'(Q) + [p'(Q) - c''(q_f)]}.$$

If Assumptions (1-3) hold then the strict log-concavity property of the inverse demand function and strict-convexity of the cost function ensure us that the nominator in absolute value is less than denominator in absolute value. Consequently $\frac{dq_f}{dQ^h} \in (0, -1)$.

Although the aggregate output is increasing in the home industry production since $\frac{dQ}{dQ^h} = \frac{d\left[Q^h + q_f(Q^h)\right]}{dQ^h} = 1 + \frac{dq_f}{dQ^h} > 0$, Assumption 4 indicates that there is a level of home industry output at which a further increase in Q^h reduces the domestic welfare. The presence of the foreign firm in the domestic market is associated with two contradicting effects. It increases consumers' surplus by providing the commodity at a lower price. At the same time, it reduces the home industry profits and transfers part of the profits to abroad. Thus, it is not in the domestic economy's interests to supply all the demand only from the domestic producers or the foreign firm when the technology in the home industry is decreasing returns to scale. This consideration forces the domestic government to leave some part of the home market to the foreign competitor.

4.1 The Ideal Setting

In an ideal setting, the economy produces up to a point where the benefits of an additional unit of output is equal to its social costs provided that it is produced efficiently. Suppose there exists an aggregate cost function for the home industry $C(Q^h)$ along which the allocation of production of any output level among the domestic firms is cost minimising and the home industry can enjoy the first-mover-advantage. Using the chain rule in anti-differentiation, the welfare maximisation problem of the domestic economy is

(11)

$$\underset{Q^h \in S_h, q_f = q_f(Q^h)}{\text{Max}} \quad W(Q^h, q_f) = \int_0^{Q^h} p(t)\left[1 + \frac{dq_f}{dQ^h}\right] dt - p(Q)q_f - C(Q^h).$$

Solving the first order condition of maximisation problem (11) for the price yields the necessary conditions of an optimal allocation for the domestic economy:

$$(12) \qquad \begin{cases} i)\ p(Q^*) = C'(Q^{h*}) + p'(Q^*)\left[1 + \dfrac{dq_f}{dQ^h}\right] q_f^* \\ ii)\ Q^{h*} = 2q^{h*}. \end{cases}$$

where q^h is the output of each domestic firm irrespective of its ownership. The second condition of an optimal allocation refers to productive efficiency. We call the first condition in (12) as adjusted marginal cost pricing condition which is the optimal pricing condition of the home industry in the presence of a foreign competition and define it as follows.

> DEFINITION 1: *The* ***adjusted marginal cost pricing (AMCP)*** *condition is said to be a pricing condition which requires the domestic firms to produce at the point where the sum of the marginal reduction of the value of imports, due to change in price (caused by an additional unit of the domestic firm's production), and its marginal cost is equal to the market price.*

As $p'(Q) < 0$ and $\dfrac{dq_f}{dQ^h} \in (0, -1)$ whenever $p(Q) > 0$, the AMCP condition leads to an equilibrium price that is less than MCP. This is not surprising. Let start with the case of the domestic acquisition of the foreign firm. Then the optimal pricing condition is MCP provided that $\alpha = 1$. If however, the industry profit is valued less than the consumers' surplus, the equilibrium price would be below the MCP condition (see Eq. 7). In the presence of international competition just part of the industry profit – that is the total industry profit less the profit of the foreign firm – appears in the objective function of the domestic government. Therefore, likewise the equilibrium price is less than MC.

4.2 A State-Owned Industry

In the state-owned industry, since the public sector sets its output in advance of the foreign firm, it always follows AMCP condition by definition. But recall that the slope of the foreign firm's best response function in absolute value is less than one. It follows that, even at optimum, the operation of the public firm may result in a loss which cannot be attributed to mismanagement of the public firm. The budget deficit of the public firm is a well-known problem in the presence of a fixed cost. But in this model even without fixed cost still the public firm may operate at a loss at the optimum.

4.3 A Regulated Privatised Industry

In a regulated privatised industry regime, a two stage-game is applied. At stage 1, the government uses subsidies to regulate the market. Otherwise, the home industry produces an aggregate level of production Z which is less than the optimal level of output Q^{h*}. At stage 2, taking the announced subsidy as given, firms choose their outputs simultaneously to maximise profits. Recall that the best response of each domestic private firm is monotone and decreasing in the output levels of its rivals and the slopes of the best response functions of the domestic private firms also are limited to the interval $(-1,0)$ for the same reason as stated in Lemma (2). Hence, the best response functions satisfy both HAHN's condition and SEADE's stability conditions.[4] These ensure that with changes in subsidies the output of the home industry increases and imports fall such that all possible combinations of the home industry outputs and the foreign firm's outputs along the best response function of the foreign firm are captured. Also $Q^h(s) \in [Z, \bar{Q})$ and $s \in [0, \bar{s})$ where $\bar{s}$ is a level of subsidy of which $Q^h(\bar{s}) = \bar{Q}$. Now we claim that

PROPOSITION 2: *In the presence of a foreign firm, if the government uses subsidies optimally, the equilibrium behaviour of the domestic private firms is such that the AMCP conditions are met.*

PROOF: Summing the first order conditions of the profit maximisation problem of two identical domestic private firms yields

$$p(Q) + \frac{p'(Q)Q^h}{2} + s = c'(q_m). \tag{13}$$

Adding and subtracting $p'(Q^*)\left[1 + \frac{dq_f}{dQ^h}\right]q_f^*$ to both sides in Eq.(13), then we have

$$\begin{aligned} & p(Q^*) + \left\{\frac{p'(Q^*)Q^{h*}}{2} + p'(Q^*)\left[1 + \frac{dq_f}{dQ^h}\right]q_f^* + s^*\right\} \\ & = c'(q_m^*) + p'(Q^*)\left[1 + \frac{dq_f}{dQ^h}\right]q_f^*. \end{aligned} \tag{14}$$

Comparing Eq.(14) with the AMCP condition in (12) we may conclude that the terms in bracket must be equal to zero if we are at the optimum. Therefore, the optimal subsidy is

4. The HAHN condition requires a decreasing marginal revenue of each firm in its rival's output or simply the downward-sloping best response functions. Based on SEADE's conditions the absolute value of the slope of the best response functions should be less than 1 then Cournot equilibrium of a homogeneous good is stable. For a strictly convex cost function with linear demand these conditions are always met.

(15) $$s^* = -p'(Q^*)\left[\frac{Q^{h*}}{2} + \left(1 + \frac{dq_f}{dQ^h}\right) q_f^*\right].$$

Since $\dfrac{dq_f}{dQ^h} \in (-1.0)$, $s^* > 0$. Also $s^* < \bar{s}$ because $Q^h(s) < \bar{Q}$ and it is monotone and increasing in s, hence $s^* \in [0,\bar{s})$. The uniqueness of the optimum from Assumption (4) ensures that s^* in Eq.(15) is unique. Once it is implemented, the conditions of AMCP are met for each domestic firm in equilibrium. ■

At the optimum the output levels of firms in the home industry are the same and both domestic public and private firms follow the AMCP condition.

EXAMPLE 1: *Suppose that the inverse demand function is characterised by* $p(Q) = a - Q$ *and the firms' cost function can be represented by* $c(q) = (k/2)q^2$. *Then* $p'(Q) = -1$. *Also it can be checked that in a regulated privatised setting* $\left[1 + \dfrac{dq_f}{dQ^h}\right] = \left(1 - \dfrac{1}{k+2}\right)$ *and the SPNE level of optimal output of foreign and domestic firms are* $q_f^* = [(2+k)ka]/(12k + k^3 + 6k^2 + 6)$ *and*

$q_m^* = \left(k^2 + 4k + 3\right) a / \left(12k + k^3 + 6k^2 + 6\right)$ *respectively. Based on (15), the optimal subsidy is*

$$s^* = \frac{\left(k^2 + 4k + 3\right) a}{\left(k^3 + 6k^2 + 12k + 6\right)} + \left(\frac{k+1}{k+2}\right) \frac{(2+k)ka}{\left(k^3 + 6k^2 + 12k + 6\right)}$$
$$= \frac{a(2k+3)(1+k)}{(k^3 + 6k^2 + 12k + 6)}.$$

This corresponds to the exact value of the optimal subsidy in PAL & WHITE *([1998], p. 268).*

4.4 A Mixed Market Structure

In a regulated mixed market structure, the domestic industry consists of one public firm, one domestic private firm and one foreign firm. Again we consider both public firm STACKELBERG leadership and COURNOT competition. In the public firm STACKELBERG leadership game, at the first stage of a two-stage game, the public firm chooses its output level to maximise welfare while the government chooses the level of subsidy to induce the welfare-maximising behaviour of the domestic private firm. In the second stage the private firms, taking the level of subsidy and the output level of the public firm as given, choose outputs simultaneously to maximise their own profits. If the domestic firms in this setting also follow the AMCP condition in equilibrium, then the irrelevance result can be proved in general.

PROPOSITION 3: *If the domestic market is open to foreign competition and the government of the home country uses a subsidy to the production of the domestic private firms optimally before and after privatisation, the equilibrium levels of the optimal subsidy and welfare are identical irrespective of whether i) firms are involved in a public firm* STACKELBERG *leadership game in a mixed market structure or ii) the public firm is privatised and regulated by a subsidy while it moves simultaneously with other private firms in a* COURNOT *competition.*

PROOF: Proposition (2) shows that the domestic private firms follow AMCP condition in the regulated privatised industry. To prove this proposition we need to show that in a regulated mixed market structure also firms follow AMCP condition. Maximising (1) and (2) by the private firms in the second stage we have

$$(16) \qquad \begin{cases} i)\ p'(Q)q_f + p(Q) - c'(q_f) = 0 \\ ii)\ p'(Q)q_m + p(Q) - c'(q_m) + s = 0 \end{cases}.$$

These yield $q_m(s,q_n)$ and $q_f(q_m(s),q_n)$ as the equilibrium outcome of the game at the second stage. At the first stage the government chooses q_n and s to maximise $W(q_n,q_m(s,q_n),q_f(s,q_n))$. The equilibrium condition of the first stage requires

$$\begin{cases} \dfrac{\partial W}{\partial q_m}\dfrac{\partial q_m}{\partial s} + \dfrac{\partial W}{\partial q_f}\dfrac{\partial q_f}{\partial q_m}.\dfrac{\partial q_m}{\partial s} = 0 \\ \dfrac{\partial W}{\partial q_n} + \dfrac{\partial W}{\partial q_f}\dfrac{\partial q_f}{\partial q_n} + \dfrac{\partial q_m}{\partial q_n}\left[\dfrac{\partial W}{\partial q_m} + \dfrac{\partial W}{\partial q_f}\dfrac{\partial q_f}{\partial q_m}\right] = 0 \end{cases}$$

Since $\dfrac{\partial q_m}{\partial q_n} > 0$, the first stage equilibrium conditions can be reduced to

$$(16) \qquad \begin{cases} iii)\ \dfrac{\partial W}{\partial q_n} + \dfrac{\partial W}{\partial q_f}\dfrac{\partial q_f}{\partial q_n} = 0 \\ iv)\ \dfrac{\partial W}{\partial q_m} + \dfrac{\partial W}{\partial q_f}\dfrac{\partial q_f}{\partial q_m} = 0. \end{cases}$$

But $\frac{\partial W}{\partial q_n} + \frac{\partial W}{\partial q_f}\frac{\partial q_f}{\partial q_n} = p(Q^*) - c'(q_n^*) - p'(Q^*)\left[1 + \frac{dq_f}{dq_n}\right]q_f^*$ that is exactly the AMCP condition. Note that the optimal subsidy in (15) will not change if after public acquisition the firm still follows the AMCP condition. Therefore, both public and private firms following the AMCP condition and, the uniqueness of the optimum ensures that the level of optimal subsidy and welfare are the same for a regulated privatised industry and a regulated mixed industry regime. ■

If the irrelevance result holds even in the presence of a foreign firm in a regulated market by optimal subsidy, privatisation in such a market cannot improve welfare. The possibility of welfare improvement of privatisation crucially depends on how the interaction of firms in the market is modelled. For instance if following PAL and WHITE [1998] we assume that the public firm moves simultaneously with the private firms, then

LEMMA 3: *The equilibrium output of the public firm in a regulated mixed structure industry is higher if the public firm moves simultaneously with private firms than when it acts as a STACKELBERG leader.*

PROOF: Suppose at the second stage the public firm maximises (3) taking q_f, q_m and s as given in a COURNOT competition. From the first order condition for interior solution of the firms' problems at the second stage of the game, we have

$$(17)\qquad \begin{cases} i)\ p'(Q)q_f + p(Q) - c'(q_f) = 0 \\ ii)\ p'(Q)q_m + p(Q) - c'(q_m) + s = 0 \\ iii)\ p(Q) - c'(q_n) - p'(Q)q_f = 0. \end{cases}$$

Let $\left(q_n^0\left(q_m^0(s)\right), q_m^0(s), q_f^0\left(q_m^0(s)\right)\right)$ be a vector that can solve (17 i-iii) for any given level of subsidy. Then from the government maximisation problem at the first stage of the game

$$\frac{dW}{ds} = \frac{\partial q_m}{\partial s}\left[\frac{\partial W}{\partial q_n}\frac{\partial q_n}{\partial q_m} + \frac{\partial W}{\partial q_m} + \frac{\partial W}{\partial q_f}\frac{\partial q_f}{\partial q_m}\right] = 0.$$

which implies

$$(17)\qquad iv)\ \frac{\partial W}{\partial q_m} + \frac{\partial W}{\partial q_f}\frac{\partial q_f}{\partial q_m} = 0$$

since $\frac{\partial q_m}{\partial s} > 0$ and $\frac{\partial W}{\partial q_n} = 0$. Eqs. (16 i-iv) and (17 i-iv) differ only in (16 iii) and (17 iii). A comparison between (16 iii) and (17 iii) indicates that $q_n^0 > q_n^*$, because $\frac{dq_f}{dq_n} \in (-1,0)$ and $p'(Q) < 0$. Thus the public firm produces more when it moves simultaneously. ■

In brief, the outcome of this section has the following implications. First, when the public firm moves simultaneously with private firms, domestic public firm and domestic private firm do not produce equally and this violates the productive efficiency. Second, as COURNOT outcome differs from the public sector leadership equilibrium outcome (Lemma 3), and the public firm could have chosen its simultaneous play strategy when it has a first-mover-advantage, it follows that the public firm STACKELBERG outcome is socially preferable to COURNOT outcome.[5] Third, moving simultaneously with private firms the public firm not only hurts the home economy but also put excessive pressure on the foreign firm. This implies that the foreign firm is also better off if it is involved in a public firm STACKELBERG leadership game.

5 Conclusion

This paper investigates the effects of public enterprise strategies in a regulated domestic market open to foreign competition through different scenarios. While PAL and WHITE [1998] argue that in an international mixed oligopoly the domestic country always is better off by privatising the welfare-maximising public firm even if it is just as efficient as the private firms, a comparison of the results under different regimes shows that the welfare gain of privatisation can well be explained by giving the first-mover-advantage to the public enterprise in a mixed market structure.

To summarise, this study suggests that in the presence of international competition, we may concentrate on timing of the game as a source of inefficiency in a regulated mixed market structure rather than the ownership of the domestic firms in the home industry. Since the timing of the game has such a crucial impact on the results, it is desirable to provide a rationale for any assumption regarding the timing of the game. To address the question of choosing an appropriate assumption about the order of firms' moves, further research in this area can extend the game to a preplay stage, wherein firms can choose the time of action rather than acting in an ordered time. ▼

5. I would like to emphasise that we do not claim the public firm leadership is always preferable. We are aware that, even in a closed economy, it might be preferable for the public firm to act as a follower (see BEATO and MAS-COLELL [1984]). Also in the presence of a foreign firm, an example can be constructed in which the domestic country will be better off, if the publicly-owned enterprise acts as a follower. The main lesson of the present analysis is that the outcome depends on the timing structure of the game.

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APPENDIX

A) Let $q_m(s)$ and $m = 1,2$ be the solution of the second stage of the game. At the first stage the government chooses s to maximise $W(q_1(s), q_2(s))$. From the FOC for interior solution of the government problem

$$\frac{\partial Q}{\partial s}\{p(Q^*) - \alpha c'(q_m^*) - (1-\alpha)[p'(Q^*) + 1/(\partial Q/\partial s)]Q^* \\ -(1-\alpha)(p(Q^*)+s^*)\} = 0 \tag{18}$$

where $\frac{\partial Q}{\partial s} > 0$ whenever $p(Q) > 0$. Summing up the FOCs of the private firms' problem at the second stage and, adding and subtracting $\left(\frac{1-\alpha}{\alpha}\right)\left[p'(Q^*)Q^* + s^*(1/\varepsilon_{Qs}+1)\right]$ yields

$$p(Q^*) - p'(Q^*)Q^*/2 - c'(q_m^*) - \left(\frac{1-\alpha}{\alpha}\right)\left[p'(Q^*)Q^* + s^*(1/\varepsilon_{Qs}+1)\right] \\ + \left(\frac{1-\alpha}{\alpha}\right)\left[p'(Q^*)Q^* + s^*(1/\varepsilon_{Qs}+1)\right] + s^* = 0. \tag{19}$$

It can be checked that (18) is satisfied by (19) if the conditions (8 *i-iii*) are met.

B) To prove this proposition we need to show that in a regulated mixed market structure under both public firm STACKELBERG leadership game and COURNOT competition the firms follow the MCP condition. Let $q_m(s, q_n)$ be the best response of the private firm at the second stage of a public firm STACKELBERG leadership game. q_n^* and s^* solve the maximisation problem of the government in the first stage of the game if they satisfy the following equations

$$\begin{cases} i)\ p(Q^*) - c'(q_n) + \frac{\partial q_m}{\partial q_n}\left[p(Q^*) - c'(q_m)\right] = 0 \\ ii)\ \frac{\partial q_m}{\partial q_n}\left[p(Q^*) - c'(q_m^*)\right] = 0 \\ iii)\ Q^* = 2q_i^* \qquad i = n,m \end{cases} \tag{20}$$

In a COURNOT competition if $q_n(q_m(s))$ and $q_m(s)$ are the equilibrium output of firms at the second stage of the game then the solution of the government's problem at the first stage of the game requires

$$\text{(21)} \qquad \left[p(Q^*) - c'(q_n)\right] \frac{\partial q_m}{\partial q_n} \frac{\partial q_m}{\partial s} + \frac{\partial q_m}{\partial s} \left[p(Q^*) - c'(q_m)\right] = 0.$$

It is obvious that the MCP condition satisfies both equilibrium conditions and the uniqueness of the optimum ensures us that there is no other candidate for SPNE of the game.