THE PROVISION OF PUBLIC INPUTS IN OLIGOPOLISTIC MARKETS

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1 INTRODUCTION

Optimal rules for the provision of collective factors of production have been quite extensively investigated since the seminal contributions of Kaizuka (1965) and Sandmo (1972), that may be regarded as the counterpart of the Samuelson's papers on the optimal allocation of public goods among consumers (1). In the works of Kaizuka and Sandmo, conditions for productive efficiency were explored and general equilibrium implications of such conditions were derived in terms of correct shadow prices to be used in the provision of public inputs by a central planner (2).

A further extension in this line of research was brought in by Laffont (1975) who showed how the introduction of uncertainty in the provision of public inputs substantially modifies the optimal rules obtained in the afore-mentioned papers, even assuming complete knowledge about the cost structure of the private firms interested in the production of the public input (3).

More recently Kohli (1985) discussed the properties of cost and profit functions that include a quite peculiar type of public input, deriving duals for some well-known theorems in international trade theory under the assumption of non-jointness in the production set (4).

All these contributions have been set up in a general equilibrium framework in analogy with the literature on public consumers goods and according to the prevailing tradition in public economics literature, whose major and quite justifiable concern was how to derive optimal provision and pricing rules in order to discuss the allocative and distributive properties of public interventions[(5)].

The only notable exception to this tendency is the Groves and Loeb (1976) paper that tackles the issue of designing an economic mechanism capable of coordinating the provision of a public input to a group of private firms without incurring in the "free rider" problem. This otherwise interesting exception is mainly due to the fact that the "more limited" object of the paper of Groves and Loeb is inherently so complex that could hardly have been undertaken in a general equilibrium context that remains however - in the authors' opinion - the most suitable framework to work with public inputs[(6)].

1.1

This traditional focus on the conditions of Pareto optimality in the provision of public goods has however generated a quite diffused disregard towards the role that the market structure of the industries involved in such provision can play in modifying the allocative properties of the optimal rules designed under the perfect competitions assumptions. In this respect it could be reasonable to argue that the introduction of a public input in an oligopolistic market has almost certainly very different effects on price, output and on other important variables that influence its allocative properties respect to the same provision in a competitive structure[(7)]. In what follows we therefore assume the presence of a public agency producing different types of public input that enter the cost fuctions of n oligopolistic firms producing an homogenous private output. The effect of the public input is to shift the cost parameters of the private firms downwardly in a symmetric or asymmetric way, according to a simple variational conjectures scheme that allows for different degrees of collusion among them[8].

The model is mantained at a very simple level - as for strategic interaction and informational requirements - in order to show which are the main features of the oligopolistic markets that make the standard results in public economics not appropriate in this context.

1.2

Following the structure of the Seade (1985) model of taxation in oligopolistic structures - one of the few studies in this very interesting area - we show that a marginal increase in the provision of public factor-augmenting inputs always increases the output of the industry, but not so for the profits, whose variation may well be negative when the demand is particularly non elastic. In this case it is also shown that the fall in the cost parameters almost always - but not in the competitive case - overcomes the price decrease.

On the other hand when firm-augmenting or local public inputs are introduced, the industry output increases - coeteris paribus - with an elastic demand, whereas there may be firms actually reducing their output. Moreover, when the public input is firm-augmenting, the more efficient firms tend to increase their output relatively less in front of an increase in the provision of the input. In these circumstances it is also possible for some firms to have their costs decreased by a smaller amount than the price fall, again according to some critical elasticity levels. Quite surprisingly overall profits may be negative in this case when the opposite conditions respect to the symmetric case hold, namely when the demand is elastic.

Further, some welfare calculations show that - with equal production costs for the provision of the factor-augmenting public inputs - the former ones tend to be more welfare-improving when the elasticity of demand is low and vice versa.

The main object of the exercise is however to show how some well-known results in industrial economics literature can be put to work in a context traditionally investigated only by public economics authors. In doing this is obviously quite easy to incur in shortcomings in both the areas that we would like to cover (9). For now it will be only noticed that no attempt has been made all through the paper in order to endogenize the cost of producing the public input, or to include this cost in the welfare analysis that compares different types of input, since is generally assumed that they are covered by general taxation.

1.4

In the second section we sketch out the basic lines of the model in the case of factor-augmenting public input when a symmetric environment is needed. Static comparative results on output, price and profits are derived following the framework developed in Seade (1985). In the third section similar results are obtained for both "local" public inputs and firm-augmenting ones and in the following section a comparative welfare analysis of the provision of those different public inputs is provided. In the concluding remarks some suggestions for further research are included.

2 FACTOR AUGMENTING PUBLIC INPUTS

Public intermediate goods are in general factors of production that enter the cost function of several firms. In the public economics literature however, they have been differentiated according to the particular way in which they enter these functions. More precisely McMillan (1979) distinguishes between factor-augmenting and firm-augmenting public inputs; the former ones are those that are available for the use by any primary factor, whereas the latter ones are available for the use of any firms in an industry, but firms of different size can use the same quantity of public input[10]. It is then clear that the effects of an increase in the provision of factor-augmenting public inputs, in terms of cost parameter shifts, can be analyzed in a model with symmetric firms, whereas in order to study the implications of the introduction of a firm-augmenting public input, it is necessary to start from an asymmetric model. In this section we will analyze the first category, leaving the other to the next one.

2.1

The n symmetric firms - producing a homogeneous output - confront an inverse demand section $p=p(Q)$, with $p'<0$, $p''<0$ and Q indicating the industry output. The cost function for the firm i is defined as

$$c^i = c(q^i, g)$$

where q^i is its output and g is the amount of the public input provided by the agency. The cost function is characterized by $c^i_{qq}>0$ and $c^i_{qg}<0$ for every i[11] where subscripts indicate differentiation.

The profit function for the firm i is given by

$$\pi^i = p(Q)q^i - c^i(q^i, g). \tag{1}$$

Differentiating (1) w.r.t q^i we do not obtain the marginal profit perceived by the firm i, since we assume that it believes that the other firms' output will change in relation to its own by a simple conjectural variation relation such as

$$k^i = dQ/dq^i$$

with $k^i=0$ in a competitive sector, $k^i=1$ in a Cournot environment and $k^i=Q/q^i$ if the firms conjecture that their change in q^i will encounter an equiproportionate response by the others. Accordingly the first and second order conditions for the firm i are respectively

$$p(Q) + p'(Q)k^i q^i - c^i_q(Q,g) = 0 \tag{2}$$

and

$$k^{i2}q^i p'' + 2k^i - c^i_{qq} < 0. \tag{3}$$

The stability conditions for this equilibrium have been derived by Seade (1980) under conditions of asymmetry among firms and are as follows

$$(n+k^i)p' + nk^i q^i p'' - c^i_{qq}$$

and

$$k^i p' - c^i_{qq} < 0. \tag{4}$$

In order to obtain the output reaction function of the representative firm to a marginal increase in the provision of the public input we totally differentiate (2) and we consider - as a first case - a symmetric equilibrium, obtaining

$$\frac{dq}{dg} = \frac{c_{qg}}{(n+k)p' + nkqp'' - c_{qq}} \tag{5}$$

which, from the stability conditions (4) is always positive under symmetry. Moreover it is easy to verify that (5) is greater in the case of competitive behaviour (k=0), then under Cournot assumptions (k=1) and smallest under a market share equilibrium (k=n). As usual the more collusive is the market, the smaller is the raction of the producers in terms of output.

2.2

Due to the homogeneity assumption, the price variations can be easily derived differentiating p(Q)=p(nq) with respect to g

$$\frac{dp}{dg} = \frac{p'nc_{qg}}{(n+k)p' + nkqp'' - c_{qq}} \tag{6}$$

that is, as expected, positive. Following Seade (1985) we define the shifting coefficient

$$s = (dc_q/dg)/(dp/dg) \cong (\Delta c_q - \Delta p)/\Delta p \tag{7}$$

that measures the proportional amount by which the variation in price undershifts the variation in marginal costs. From (6) it is possible to derive the value of s in our case

$$s = (k/n)\ (1 + (nqp''/p') - (c_{qq}/kp')) \tag{8}$$

from which defining $E=-Qp''/p'$ as the elasticity of the slope of the inverse demand (Seade 1980)) and $1-x=(c_{qq}/kp')$ as the effect on own marginal costs per unit of perceived change in price, (8) can be rewritten as

(9) $$s = (k/n)\ (x - E).$$

Assuming a linear cost structure such as $c_{qq}=0$ and recalling the definition of s, there will be an undershifting of price on marginal costs when $E<1$. Since the expression (3) and (4) can be formulated in terms of E and x as

(3') $$E < (1 + x)\ n/k$$

and

(4') $$E < n/k + x \qquad k > 0$$

and since $n/k\geq1$, the conditions for undershifting are compatible with the stability and the second order conditions.

Some observations can be derived from the expression (9). Firstly the occurrence of over or undershifting does not depend either on the structure of the market in terms of number of oligopolistic firms involved or on their conjectural variation parameters. These features of the market structure can only increase or decrease the value of s, whose algebraic sign is strictly determined by the cost structure and the shape of the demad curve.

Secondly, the possibility of over and undershifting only arises when there is strategic interaction among firms because under competitive conjectures s is bound to be 0. On the other hand, the more the market is collusive, the higher are the under or overshifting effects and that, if it is intuititve with undershifting, it is certainly not in the opposite case.

Thirdly, the presence of an isoelastic inverse demand function and of a linear cost structure makes overshifting unavoidable. In fact with $p=Q^{-1/e}$ the value of E becomes $E=1+1/e>1$. On the contrary under a linear inverse demand function, whatever it is the cost structure, $E=0$ and so undershifting always occurs. The fact that the possibility of under or overshifting heavily depends on the structure of the demand curve has been already noticed by DeMeza (1982) and Stern (1982).

2.3

The effect of a marginal increase in the provision of the public input is not a priori completely clear because if the price level will certainly decrease in absolute terms, it is also true that the output increases for any firm in a way that is correlated with their strategic interaction. To see which effect will prevail and under which conditions we totally differentiate (1) obtaining

$$(10) \qquad \frac{d\pi}{dg} = \frac{(n-k)\ qp'c_{qg}}{(n+k)p' + nkqp'' - c_{qq}} - c_g .$$

Since both c_{qg} and c_g are negative by assumption, n is the upper limit for k and the denominator is negative for the stability conditions (4), the expression (10) describes two opposite effects on profits: the first being the increased equilibrium output effect which has a negative influence on profits and the second being the profit gains obtained by the producers in absence of the equilibrium effect. Obviously which of the two effects will prevail depends on the features of the cost and demand structure with a number of possible outcomes. It may be interesting however to specialize our assumptions on a particular class of cost functions of the form

(11) $$c(q,g) = aq + Q/g$$

where obviously $c_g=-Q/g^2$, $c_{qg}=-1/g^2$ and $c_{qq}=0$. Accordingly (10) becomes

$$\frac{d\pi}{dg} = \frac{qk(2p' + nqp)}{[(n+k)p'+nkqp'']g^2}$$

and, substituting with E and x

(12) $$\frac{d\pi}{dg} = \frac{qk\ (2-E)}{[(n+k)p'+nkqp''-c_{qq}]g^2/p'} .$$

From (12) it is easy to verify - always recalling conditions (4) - that a marginal increase in the provision of the public input has a positive effect on profits only if there are no competitive variational conjectures and if $E<2$.

In this case also the market structure does not actually determine the sign of the expression (12) even if it is still true that the more collusive is the market, the greater is the impact of the marginal increase in public input provision on profits in either directions.

Adopting an isoelastic inverse demand function, the condition $E<2$ is equivalent to $e>1$ in terms of elasticity of the ordinary demand curve. This means that in a symmetric oligopoly an increase in the provision of public input increases profits only when the demand is elastic. Again this result is heavily dependent on the assumptions about the demand structure insofar a linear demand curve would increase profits in any circumstances, with the only exception of competitive behaviour. It should be noticed also that under monopolistic conditions a negative value of (12) can never occur, even with an isoelastic demand, because in that case the elasticity of the ordinary demand curve is always greater than the one in equilibrium.

There is however a requirement that we have to impose on (12), namely the stability conditions (3') and (4'), in force of which with an isoelastic demand curve and a linear cost function (12) becomes

$$e > k/n \qquad (13)$$

that says that stable equilibria imply $e>1$ only when there is a highly collusive conjectural variation parameter. If there are behaviour rules different from a market share agreement the condition to mantain (12) positive cannot create problems in terms of stability.

3 LOCAL AND FIRM AUGMENTING PUBLIC INPUTS

In the preceding section we analyzed the impact of marginal variation in the provision of a public input that entered the cost function of each firm in the same way. This kind of public intermediate goods are known in the literature as factor-augmenting public goods since the total amount of the latter is available for use by any primary factor and altering the firm's size does not alter the amount of public good is available to work with. This feature obviously allows its introduction in a symmetric equilibrium analysis.

3.1

It is however possible to consider public inputs not entering the cost function of every firm in the same way. One very important case that may arise is a local public input that does not affect the cost structure of the firms operating outside the territory where the factor is provided. This kind of public good has been extensively studied in international economics theory in order to deal with otherwise unexplainable cost differentials between firms competing in the same international sector[11]. Another case that has been investigated in the public economics literature is that of a firm-augmenting public input. With this definition is indicated a production factor that is available for use by any firm in an industry, but firms of different size use the same quantity of public good. With such an input there is no exclusion of use among firms but within a firm there is exclusion of use among factors[12].

The distinction between the two categories of public inputs lies in the fact that in the former the publicness ends on the border of a territory whereas in the latter it ends inside the firm at the factor level. For our purpose both cases need to be studied in a model in which firms are asymmetric in the precise meaning that the public inputs enters in different ways in the cost functions of different firms. The firm-augmenting public input will be that case in which the difference is given by the size (or market share) of the firm itself.

3.2

In order to study the impact of these "asymmetric" public inputs we need to rewrite the first order conditions mantaining the distinction across firms

$$(14)\quad p'\Sigma_j dq^j/dg+k^i q^i\Sigma_j dq_j/dg+k^i p'(dq^i/dg)-c^i{}_{qq}(dq^i/dg)-c^i{}_{qg}=0$$

Using the conditions for stability and defining

$$\sigma^i = (p' + k^i q^i p'')/(k^i - c^i_{qq})$$

and

$$\delta^i = c^i_{qg} / (k^i p' - c^i_{qq}) \qquad (15)$$

it is possible to simplify (14) as

(16) $$\sigma^i \Sigma_j (dq^i/dg) + dq^i/dg = \delta^i$$

which, upon addition becomes

$$\Sigma_j \, dq^j/dg \, (1 + \Sigma_j \sigma^j) = \Sigma_j \, \delta^j$$

and, using $(1+\Sigma_j \sigma^j)>0$ from (4), we get

(17) $$\Sigma_j (dq_j/dg) = (\Sigma_j \delta_j)/(1+\Sigma_j \sigma^j).$$

The expression (15) is positive under our assumptions, since it is such when $c^i_{qg} \leq 0$ and $c^i_{qg} < 0$ for at least some of them. As far as the individual firm i is concerned its output will increase when

(18) $$(dq^i/dg) = \delta^i - \sigma^i (\Sigma_j \delta^j / 1+\Sigma_j \sigma^j)$$

is positive. That may occur, under stability conditions, only when $\delta^i > 0$, that is when the cost reduction due to the marginal increase in the public good provision is high enough in that specific firm i. It follows that, in the case of local public input will decrease its output, and therefore the rival ones will increase their in a way to more than compensate the first effect.

3.3

We now specialize our model assuming linear costs, Cournot-Nash behaviour and $c^i_{qg}=\alpha/q^i$ in order to introduce the analysis of a firm-augmenting public goods whose impact on the cost structure is inversely related to the market share of the firm. In this case (15) becomes

$$\sigma^i = (1+q^i(p'/p'')) = (1-(q^i/Q)E)$$

and

$$\delta^i i = \alpha/q^i p'$$

where $\alpha<0$ and (17) may be written as

$$(19) \qquad \Sigma_j(dq^j/dg) = a/[p'(2-E)]$$

where $a=\alpha/Q$. The expression (19) is positive when $E<2$ and therefore always with a linear demand and when $e>1$ with an isoelastic inverse demand. Accordingly (18) now becomes

$$(20) \qquad dq^i/dg = (\alpha/q^i p')+[(q^i/Q)E-1]\ [a/(p'(2-E))]$$

The sign of the latter depends on both E and the market share. It is to be noticed that the first term in (20) can be regarded as the positive effect on output of cost decreasing and it is inversely related with q^i whereas the second term has a positive (negative) effect on the output if $E>2$ $(E<2)$ that is directly related with the market share. It follows that the smaller is E or the more elastic is the ordinary demand, the more is penalizing - in terms of output - to be characterized by an high market share.

In fact, if the initial Cournot-Nash equilibrium allocates market shares in inverse relation to marginal costs as

$$q^i = -(p-c^i_q)/p'$$

we can see from (20) that the marginal variation of output due to an increase in the provision of the public input is actually inversely correlated with the previous level of output. Differentiating (20) w.r.t. q^i we get

$$(21) \qquad (dq^i_g/dq^i) = [\alpha E/Q^2 p'(2-E)] - [\alpha/q^{i2}p']$$

that, under our assumptions, and provided that q^i is not "too high" is negative.

This particular effect of the provision of firm-augmenting public inputs is however hardly surprising since its main explanation is to be found in the definition itself of such inputs. In fact in these circumstances, the smaller (the less efficient) is the firm, the larger is the ratio of public to private factors used by it, that is, the larger is the marginal efficiency of the private factors in the firm.

3.4

We turn now to examine possible differences arising in the behaviour of prices and profits when asymmetries in the impact of the provision of public inputs are taken into account. To mantain the analysis algèbraically tractable we assume again a linear cost structure. In this case we get

$$\frac{(dp/dg)}{dc^i_q/dg} = \frac{p'(dQ/dg)}{c^i_{qg}} = \frac{p'\Sigma_j(dq^j/dg)}{c^i_{qg}}$$

and using (17)

$$(22) \qquad [(dp/dg)/c^i_{qq}] = p'[(\Sigma_j \delta^j)/(1+\Sigma_j \sigma^j)c^i_{qq}] \ .$$

If every firm is characterized by Cournot-like conjectures from (22) we have that

$$(23) \qquad [(dp/dg)/c^i_{qq}] = (\Sigma_j \ c^j_{qq})/(c^i_{qq}(2-E).$$

Recalling the expression (8), (23) can also be written as

$$(24) \qquad s^i = (\Delta c^i_q - \Delta p)/\Delta p \cong [c^i_{qq}(2-E) - \Sigma_j c^j_{qq}]/[\Sigma_j c^j_{qq}].$$

Expression (24) allows for different comments according to the consideration of either a local or a firm-augmenting public input.

In the first case overshifting always occur for those firms who are not getting benefits from the provision of public input. For the other ones the likelihood of undershifting is directly related with E and thus inversely related with the elasticity of the ordinary demand curve. More specifically it can occur only if e<1 and if the cost reduction experienced by the firm i is a sufficiently high proportion of the overall cost reduction. When firm-augmenting public inputs are considered (24) can be written as

$$(25) \qquad s^i = (Q/q^i)(2-E) - 1$$

that shows again how firms with high market shares are disadvantaged in undershifting in those circumstances in which it may occur (i.e E<2).

One important point that should be noticed comparing expression (24) with the analogous for the symmetric case in (9) is that in the former conditions for undershifting are univocally less restrictive in terms of elasticity of the ordinary demand curve. This is due to the fact that whereas in (9) $E<1$ is - given our assumptions - both a necessary and sufficient condition for undershifting, in expression (24) $E<2$ is only a necessary condition for undershifting. It is, in fact, also needed that for the particular firm analyzed c^i_{qg} not only negative - feature that rules out all the firm not involved in the provision of the public input - but also high enough in absolute value, condition that can rule out some of the larger firms in the firm-augmenting case. It follows that direct comparizons cannot be drawn explicitely and that the apparent smaller restrictiveness of the conditions found for the expression (9) is mainly due to its greater power.

3.5

In order to detect the impact of an increase in the provision of public inputs on profits when such intermediate factors enter asymmetrically in the firms' cost functions we can totally differentiate expression (1) obtaining the counterpart of (10)

$$(26) \qquad d\pi^i/dg = (p-c^i_q)\ (dq^i/dg) + q^i(dp/dg)$$

that, using (18) and (23) can be written as

$$(27) \quad d\pi^i/dg = (p-c^i_q)[\delta^i-(\sigma^i\Sigma_j\delta^j/1+\Sigma_j\sigma^j)]+q^i[\Sigma_j c^j_{qg}/(2-E)]$$

that is positive when $\delta^i>0$, with exception for very small values of E, whereas can be more easily negative for firms that are excluded by the provision of local public inputs for whom $\bar{\delta}^i=0$. Specializing the model to firm-augmenting public inputs and recalling (20) and (23), (27) can be reformulated

$$d\pi^i/dg=(p-c^i_q)[(\alpha/q^i p')+((q^i/Q)E-1)(\alpha/Qp'(2-E))]+(q^i\alpha/Qp'(2-E))$$

that differentiate w.r.t. q^i gives

$$(28) \qquad d\pi^i{}_g/dq^i = [\alpha(E+Q)/Q^2p'(2-E)] -[\alpha/q^{i2}p']$$

that in analogy to (21) is negative always when E>2 and/or when - coeteris paribus - q^i is not too high: This result seems worth to be outlined because (28) shows a non linear influence of the market share on the sign of the profit variations due to a grater public input provision. More precisely (28), quite apart from the value of E, indicates that the marginal variation in profits tend to be smaller as the market share increases, but this does not hold in the case of firms having a very high market share that probably manage to mantain positive variations in the profit level.

In order to obtain the overall variation in profits we add up in (26) using (17) and (23)

$$\Sigma_j(d\pi^j/dg)=\Sigma_j[(p-c^i_q)(\delta^j/1+\sigma^j) + q^j c^j_{qg}/(2-E)]$$

that can also be written as

$$(29) \qquad d\pi/dg = [(p-c_q)+p'Qc_{qg}]/p'(2-E)$$

where the variables without superscripts indicates the sum over the j firms and where (15), Cournot conjectures and linear cost structure were introduced. Expression (29) under our assumptions is positive only when E>2 and this represents a striking result as long as it reverts the conditions for the overall profitability of the provision of public inputs under symmetry obtained in (12).

Given the stability conditions derived in (4) and (4') for the symmetric case however we cannot detect any incompatibility between the condition E>2 (e<1) for the positiveness of (29) and the afore-said stability conditions unless k takes very high values indeed.

4 WELFARE ANALYSIS

Assuming that the production of public inputs of the different types analyzed is financed throught general taxation, the welfare function can be defined as

$$W = \int_0^{Q^*(g)} f(Q)dQ \;-\; \Sigma_j\; c(q^j,g)q^{*j}$$

where c is the average and marginal cost, equal for each firm, or as

$$(30) \qquad W = [e/(e-1)]\; Q^{*(e-1)/e} - c(Q^*,g)Q^*$$

Differentiating (30) w.r.t. g, we get

$$dW/dg = (Q^{*-1/e}-c)(dQ/dg) - c_g Q^*$$

that under isoelastic inverse demand becomes

(31) $$dW/dg = (p^*-c)(dQ/dg) - c_g Q^*$$

where $c_g<0$ and consequently - given (5) - (31) is always positive under the provision of a factor-augmenting public input. When the public inputs are of the local or firm-augmenting type and assuming as usual Cournot conjectures, we know from (15) and (19) that the expression (31) can be rewritten as

(32) $$dW/dg = (p^*-c)\ c_{qg}/p'(2-E) - c_g Q^*$$

that is again univocally positive only when $E<2$. The opposite case of $E\geq2$ however seems, as explained in the end of the last section, to be incompatible with the stability conditions (4) and (4') and therefore can be regarded as a less interesting case of this welfare analysis.

From (31) and(32) we can further show that through the term dQ/dg, the increase in W will be greater the less collusive the market structure is, the larger is the output level in equilibrium and the greater is the impact of the provision of the public input on the cost structure of the firms. On the other hand such an increase is negatively correlated with both theaverage cost level and the elasticity of the ordinary demand curve.

Finally, recalling (15) and (4') in (31), the latter can be rewritten as

(31') $$dW/dg = (p^*-c)[(nc_{qg})/(n+1)p'+E]-c_g Q^*$$

using again Cournot conjectures and linear costs. Comparing (31') with (32) it is easy to verify that the increase in welfare due to a marginal increase in the provision of public input is greater in the case of factor-augmenting goods only when E>2 - coeteris paribus, that is assuming that nc_{qq} in (31'), indicating the impact of the marginal increase in the provision of the public input on the n symmetric firms, is equal to c_{qq} in (32), the overall impact on the asymmetric firms -. This welfare-creating advantage of "asymmetric" public inputs seems to be explainable in terms of a smaller possibility of implementing collusive behaviour when the firms have experienced very different levels of cost reductions. From that it arises the possibility of undershifting and hence of exploiting large margins for the firms who benefit more from the marginal increase in the provision.

In this section the cost of providing different public input has not been included because it is both assumed to be covered by general taxation and to be equal between the different types so that in a comparative analysis it always cancels out. The exclusion of this feature from the analysis is notwithstanding a quite serious shortcoming since it makes more difficult to draw allocative conclusions from the results obtained.

5 CONCLUDING REMARKS

The analysis presented here was mainly justified in the introduction as a perhaps fruitful investigation in the not very much studied area of intersection between industrial and public economics. Two are the most important findings of this investigation. Firstly, it has been illustrated that the provision of public input has important effects on the behaviour of oligopolistic firms and more interestingly on the market structure, effects that modify its allocative efficiency. The way in which this influence is actually carried through depends mainly on the characteristics of the demand functions and on the type of public input involved. In that respect comparative static results are relatively clear-cut to make the analysis intelligible.

Secondly, from a welfare analysis perspective, we have shown that the costs of providing public inputs to oligopolistic industries have to be carefully considered on the basis of the effects on prices and output outlined in the preceding paragraph. Specific care should be put when the provision of a firm-augmenting public input is in order, that has been shown as being relatively less welfare-improving. Different mechanisms of private provision of public inputs should then be investigated in oligopolistic markets - ranging from the classical pigouvian approach to a ridefinition of the property rights on these factors(13).

In that perspective one of the major issues that have been completely disregarded is the derivation of the conditions under which a public input - both purely and inpurely public - can be optimally provided by private oligopolistic firms. A following step would be to analyse the informational requirements that a public agency should meet - if the aforesaid conditions do not hold - in order to provide the public input efficiently(14).

Again a different extension of the approach presented here is to examine the optimal provisin rules when the effect of the public input (i.e. scientific knowledge) on the cost function passes through some learning process or through the commitment to fixed investment. In such cases there would be the possibility of taking into account a strategic interaction not only among the private firms, but also with the public agency and there again the informational requirements would be particularly relevant.

NOTES

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1 The fact that the formulae for the optimal provision of public intermediate goods have been derived more than ten years after the works of Samuelson - even if they do not need a more sophisticated analytical background - is a signal of the scarce attention paid to this topic in the literature.

2 Expecially Sandmo (1972) draws a very neat analogy between the Samuelson's rules and the ones for the intermediate public goods; Kaizuka (1965) on the other hand is more interested in deriving conditions for productive efficiency.

3 In the introduction of his work Laffont argues that in the analysis of intermediate public goods the free rider problem is not so serious as for the consumers' public goods because the technical relations involved can be more easily detected by the public agency. This does not seem to be completely true and indeed the great development of the literature on regulation with incomplete information seems to point out the relevance of taking into account the role performed by the informational requirements in the situation under analysis.

4 Kohli (1985), for analitical reasons, considers only public intermediate goods of the firm-augmenting type. The problem with this approach, as outlined by McMillan (1979), is the

lackness of generality due to the difficulty of finding reasonable examples of goods having the specified characterstics.

5 For an interesting survey of the allocative aspects of the provision of public intermediate goods see Negishi (1973).

6 The object itself of the Groves and Loeb paper may be regarded as an implicit disagreement with the Laffont's (1975) claim that the free rider problem is not so relevant when public inputs are analyzed.

7 The partial equilibrium framework cannot be seen as a serious limitation insofar it allows for the explanation of phenomena such as the output-decreasing fall in costs.

8 Perhaps the most stimulating introduction to the comparative static analysis in oligopoly models with conjectural variations is to be found in Dixit (1986).

9 Some of the most relevant among those shortcomings will be discussed in the concluding section.

10 The reason why McMillan (1979), but also Negishi (1973), point out this distinction and not, for instance a differentiation between local and factor-aumenting public inputs, is that the former allows for the analysis of interesting features of the Euler's theorem in presence of public intermediate goods.

11 The paper of Kohli (1985) is extremely interesting in that respect, since he derives the analogous of the Stolper-Samuelson and Rybczynsky theorems in presence of public inputs.

12 The only examples of firm-augmenting public input that have been noticed in the literature are legal services or services provided by trade associations and natural resources that can be utilized by several industries simultaneously and without

interferences, but with congestion among firms in the same industry (i.e lakes).

13 Discussion on the allocative features of the property rights solutions to the public goods suboptimalities - even if in a very specific context - can be found in Katz and Shapiro (1986).

14 In this respect would be interesting to see what does change in a Groves-Loeb mechanism when strategic behaviour among the private firme is introduced.

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