

9-1973

External Diseconomies in Competitive Supply: Comment

George A. Hay
Cornell Law School, george.hay@cornell.edu

John J. McGowan
Yale University

Follow this and additional works at: <http://scholarship.law.cornell.edu/facpub>

 Part of the [Macroeconomics Commons](#), and the [Public Economics Commons](#)

Recommended Citation

Hay, George A. and McGowan, John J., "External Diseconomies in Competitive Supply: Comment" (1973). *Cornell Law Faculty Publications*. Paper 1163.
<http://scholarship.law.cornell.edu/facpub/1163>

This Article is brought to you for free and open access by the Faculty Scholarship at Scholarship@Cornell Law: A Digital Repository. It has been accepted for inclusion in Cornell Law Faculty Publications by an authorized administrator of Scholarship@Cornell Law: A Digital Repository. For more information, please contact jmp8@cornell.edu.

External Diseconomies in Competitive Supply: Comment

By GEORGE A. HAY AND JOHN J. MCGOWAN*

In a recent article in this *Review*, Charles Goetz and James Buchanan (G-B) assert that "... the standard description of misallocation in the presence of external production diseconomies is misleading..." because these externalities produce a "... combination of exchange-inefficiency with production-inefficiency [which] renders the construction of correction devices much more difficult" (p. 889). Stated otherwise their contention is that with external diseconomies that are internal to an industry, i.e., those that each firm in an industry inflicts on other firms in the same industry, a competitive regime in the presence of a per unit tax on output designed to eliminate the difference between private and social marginal cost will not achieve a Pareto optimum. The competitive equilibrium even after the imposition of the corrective tax lies inside the production possibilities frontier.¹

The purpose of this note is to suggest that the G-B analysis while technically correct is based on a set of assumptions that differs in a particular aspect from what we believe to be the assumptions of the neoclassical paradigm. Moreover within the framework of the neoclassical model we show the standard pre-

scription regarding a corrective tax to be correct. As it turns out, the difference between the G-B model and the neoclassical model is likely to be negligible in any meaningful application but in any case we show that in the G-B model, a lump sum tax imposed on top of the standard Pigovian per unit tax will restore full Pareto optimality.

G-B assume that the total cost function of any firm has the following specific functional form:

$$(1) \quad c_i = k + q_i^a + Q_i^b q_i \quad a > 1, b > 0$$

where q_i is the firm's own output, Q_i is the aggregate output of all other firms in the industry, and where $b > 0$ indicates the presence of a technological external diseconomy. All firms are assumed to have the same cost function.

A general version of such a cost function is the following:

$$(2) \quad c_i = g(T/n, T)$$

where c_i is total costs for firm i , T is total industry output and n is the number of firms in the industry. Since all firms are assumed to have the same cost function, efficiency requires that output be distributed evenly among them. Thus, with n firms, each will produce T/n units.²

Dropping the subscript i , we can write total industry costs for any output T as:

$$(3) \quad TC = nc = ng(T/n, T)$$

The first condition for Pareto optimality is that of production efficiency, i.e., any output T should be produced at minimal

² Near the end of their paper, G-B generalize their original cost function in the form: $f(T/n, T-T/n)$. Obviously, without further restrictions on g or f , the two are indistinguishable. We use (2) because it highlights the key neoclassical assumption more effectively, but the identical result can be obtained using the G-B version.

* Associate professors, Yale University. We are grateful to William Brainard, Joseph Stiglitz, and Martin Weitzman for helpful comments.

¹ As G-B point out, the issue involves technical rather than pecuniary externalities since it is well known that the latter cause neither exchange nor production inefficiency. Moreover we assume G-B intended to restrict their analysis to external diseconomies in the production of a final (consumption) good rather than an intermediate good. We think it is clear that the neoclassical writers have recognized that external diseconomies in an intermediate goods industry would cause the unregulated competitive equilibrium to lie inside the economy's production possibilities frontier, since producers of final products would be led to choose inefficient input combinations. However even in this case the neoclassical writers, correctly we believe, would claim that a simple Pigovian tax on the intermediate product in question would restore full Pareto optimality.

total cost to society. The policy variable for the "social planner" is T/n , or since T is given, n . Thus we wish to minimize total industry costs with respect to n for a given T . This requires:

$$(4) \quad \frac{\partial TC}{\partial n} = c + n \left(\frac{\partial c}{\partial T/n} \cdot \frac{\partial T/n}{\partial n} + \frac{\partial c}{\partial T} \cdot \frac{\partial T}{\partial n} \right)$$

$$= c + ng_1(-T/n^2)$$

$$= c - g_1 \cdot T/n = 0$$

where $g_1 = \frac{\partial c}{\partial T/n}$

$$(5) \quad \therefore g_1 = \frac{c}{T/n}$$

but $c/(T/n)$ is average costs, AC , for each firm. Therefore, efficiency in production requires that production take place in each firm up to the point where $g_1 = AC$.

The second condition for Pareto optimality is efficiency in exchange. This in turn requires that total industry output be expanded to the point where price is equal to social marginal cost. The latter is defined by:

$$(6) \quad \frac{\partial TC}{\partial T} = n \left(\frac{\partial c}{\partial T/n} \cdot \frac{\partial T/n}{\partial T} + \frac{\partial c}{\partial T} \right)$$

$$= n \left(\frac{g_1}{n} + g_2 \right)$$

$$= g_1 + ng_2$$

where $g_2 = \frac{\partial c}{\partial T}$

Thus the condition for exchange efficiency reduces to:

$$(7) \quad P = g_1 + ng_2$$

On the other hand, profit maximization for the firm requires that production be expanded to the point where price equals *private* marginal cost, MC . The latter is defined by:

$$(8) \quad MC = \frac{\partial c}{\partial q_i} = \frac{\partial c}{\partial T/n} + \frac{\partial c}{\partial T} \cdot \frac{\partial T}{\partial q_i}$$

$$= g_1 + g_2 \frac{\partial T}{\partial q_i}$$

$$= g_1 + g_2 \left(\text{since } \frac{\partial T}{\partial q_i} = 1 \right)$$

where we have used the q_i term to indicate that the marginal cost for any one firm producing T/n is defined in terms of increasing only its own output, with all other firms continuing to produce at T/n .³

We assert that a key assumption of the neoclassical paradigm is that firms regard any increase in costs caused by the diseconomy effect of higher industry output as an exogenous *shift* in their cost curves, unrelated to changes in their own or industry output.⁴ This is equivalent to the assumption that firms perceive g_2 as equal to zero.⁵

If this assumption about firms' perception of g_2 is correct, the first condition for Pareto optimality will be fulfilled, since competitive equilibrium will be established where $P = MC = AC$, which reduces to $g_1 = c/(T/n)$ as in (5). (Of course if g_2 is negligibly small, the assumption is unimportant since we see from (8) that equilibrium output and the Pareto optimal output differ by the order of g_2 . Moreover as we shall see, there is strong reason to believe that g_2 will be negligibly small in meaningful applications.)

To secure exchange efficiency, the neoclassical economists prescribed a per-unit tax on output. If that tax is set equal to ng_2 ,

³ Implicit in (8) is the assumption that the diseconomy effect is a function of total industry output independent of its distribution among firms. This assumption is not critical to the main results. We could have written (1) as $c_i = g(q_i, q_{i+1}, q_{i+2}, \dots, q_{i+n-1})$. The first-order conditions would be more complex but their nature would not change. The G-B cost function does *not* assume that the diseconomy is independent of the distribution of total output but the nature of the required tax is unaffected by this asymmetry.

⁴ John Chipman in an elegant analysis of the neoclassical argument makes this assumption most explicit.

⁵ The spirit of this assumption is identical to that under which a firm in perfect competition assumes that expansion of its own output will not affect market price.

we have as a condition for private profit maximization:

$$(9) \quad P - ng_2 = g_1$$

$$\therefore P = g_1 + ng_2 \text{ as required by (7)}$$

Thus, under what we believe to be the assumptions of the neoclassical paradigm for external diseconomies, the prescription of a per-unit tax equal to the difference between private marginal cost and social marginal cost is the correct one and is sufficient to restore the economy to a Pareto optimal position.

We note now that where n is large, as we would expect in perfect competition, ng_2 can be significant even though g_2 is negligible. Moreover, if g_2 is not negligible, a tax equal to ng_2 would be so large as to probably require a complete shutdown of the industry, or at best an output so small that atomistic competition would not be feasible and a totally different set of controls would be required. Therefore, in any case in which the prescription of a Pigovian tax could be a feasible remedy, there is reason to believe that g_2 would in fact be negligibly small, and the neoclassical assumption would not be unrealistic.

Despite the above, if firms do not ignore g_2 , then each firm expands production to the point where $P = g_1 + g_2$, and the tax required to restore exchange efficiency is changed to $(n-1)g_2$. In that event, the production efficiency condition will not be satisfied since then we will have:

$$(10) \quad P - (n-1)g_2 = g_1 + g_2 = \frac{c}{T/n}$$

thus:

$$(11) \quad g_1 = \frac{c}{T/n} - g_2$$

violating (5).

This situation can be remedied, however, if we impose in addition to the per-unit tax, a lump sum tax equal to $g_2 \cdot T/n$. Doing so will

cause competitive equilibrium to be established where:

$$(12) \quad P - (n-1)g_2 = g_1 + g_2 = \frac{c + g_2 \cdot T/n}{T/n}$$

resulting in $g_1 = c/(T/n)$ as required by (5).

Thus if firms regard the level of diseconomy as beyond their control, which we believe is the assumption of the neoclassical paradigm, the Pigovian tax guarantees Pareto optimality. Where firms recognize the relation between industry output and their own costs, the competitive equilibrium with the Pigovian tax lies inside the production possibilities frontier by a factor of the order of g_2 which it seems reasonable to expect will be negligibly small when the number of firms is large. In any case, full Pareto optimality can be restored by a lump sum tax on top of the Pigovian per-unit tax.

Examination of the G-B model reveals that the *only important difference* between it and the neoclassical model is precisely the assumption about g_2 . In the G-B model the diseconomy effect of an increase in a firm's output (and therefore total industry output) on its own costs is blended into the cost function along with direct costs and both are assumed to be fully recognized by the firm in deciding how far to expand output.

Thus G-B are correct in asserting that *in their model* the competitive equilibrium, even with the Pigovian tax equal to the difference between private marginal cost and social marginal cost, lies inside the production possibilities curve. What we have shown is that the remaining inefficiency should be negligible. In any case we have also shown that a lump sum tax added to the per-unit tax will be sufficient to restore full Pareto optimality.

REFERENCES

- J. S. Chipman, "External Economies of Scale and Competitive Equilibrium," *Quart. J. Econ.*, Aug. 1970, 84, 347-85.
- C. J. Goetz and J. M. Buchanan, "External Diseconomies in Competitive Supply," *Amer. Econ. Rev.*, Dec. 1971, 61, 883-90.

Copyright of American Economic Review is the property of American Economic Association. The copyright in an individual article may be maintained by the author in certain cases. Content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.