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121 Sewall Hall
WILLIAM MARSH RICE UNIVERSITY
Houston, Texas 77001

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Public Goods and Income Distribution: An Explanatory Comment

by

Charles E. McLure, Jr.

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1. Introduction

Recent years have seen a burgeoning of efforts to determine how government spending affects the distribution of real income. Most studies of this question involve attributing the benefits of budgetary expenditures among income groups.[1] For transfer payments (which are best treated as negative taxes) and for exhaustive expenditures providing benefits to specific and definable groups, the attributions are relatively simple to make, despite a number of thorny theoretical and methodological problems with the second group.[2] The transfers and the benefits -- usually measured in terms of the costs of providing them -- are simply attributed to income groups whose members receive the transfers or the specific benefits. But for expenditures made to provide pure public goods, which by definition are consumed in equal amounts by all,[3] the proper method of allocation among income groups has been far from obvious, and alternative arbitrary allocations have been the order of the day. Assuming expenditures on public goods either to benefit all households equally or to

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[1]A second problem, that of determining how differences in public and private spending patterns affects real private incomes by altering relative factor and product prices, or expenditure incidence, is seldom asked. On this subject see Charles E. McLure, Jr., "The Theory of Expenditure Incidence," Finanzarchiv, 30 (1972), pp. 432-453.

[2]See Charles E. McLure, Jr., "On the Methodology of Estimating Benefit and Expenditure Incidence," xerox, Rice University, 1974.

[3]Richard A. Musgrave, The Theory of Public Finance, (New York: McGraw Hill Book Co., Inc., 1959), chapter 4.

benefit households in proportion to some measure of income or wealth has been standard practice.[1] Of course the distributional implication of these alternative assumptions is that expenditures on public goods may be progressive, proportionate, or regressive in their incidence, depending upon the assumption chosen. Moreover, given the importance of such goods in many public budgets, the results for the entire budget are likely to depend crucially on the assumption one chooses.

In a recent article, Aaron and McGuire made an important contribution toward illuminating, if not settling, this totally unsatisfactory state of affairs.[2] They pointed out that under certain apparently reasonable assumptions it can be shown that "to each household should be imputed a fraction of the total value of the public good, proportional to the reciprocal of its marginal utility of private good expenditure."[3] If their analysis is accepted, the area of controversy is reduced to the shape of the relevant marginal utility schedule, the acceptability of the Aaron-McGuire assumptions, and the implications of relaxing their assumptions.

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[1] See, for example, W. Irwin Gillespie, "The Effect of Public Expenditures on the Distribution of Income: An Empirical Investigation," in Essays in Fiscal Federalism, ed. by R.A. Musgrave, (Washington, D.C.: Brookings Institution, 1965), pp. 122-186, and George A. Bishop, Tax Burdens and Benefits of Government Expenditure by Income Class, 1961 and 1965, (New York: Tax Foundation, 1967).

[2] Henry Aaron and Martin McGuire, "Public Goods and Income Distribution," Econometrica, 38 (1970), pp. 907-920.

[3] Op. cit., p. 911. (Emphasis in original) To be formally correct and consistent with their subsequent analysis, this statement should have included explicitly benefits from specific expenditures as well as private expenditures in the reference to marginal utility. In what follows references to private expenditures should be interpreted to include these quasi-private specific expenditures. Since it is not central to the issue under discussion, we shall not explore the question of how to isolate the specific portion (the fraction "a" on p. 912) of the benefits of certain government expenditures that provide specific, as well as public, benefits.

This note has several purposes. First, a simple analytical device known to virtually all students of the theory of public goods is used to provide a simplified explanation of the Aaron-McGuire model, given their assumptions. Next we demonstrate that under these same assumptions adherence to the benefit principle in the financing of expenditures on pure public goods requires that taxes be levied on the basis of equal absolute sacrifice. This implies, of course, that efforts to implement the Aaron-McGuire methodology are destined to encounter the same obstacles that have stymied efforts to base taxation on the equal absolute sacrifice version of the ability-to-pay principle. Then the model is used to determine the implications of relaxing several of the original assumptions. Finally, we provide some concluding reflections on the usefulness of the Aaron-McGuire analysis.

2. The Model Simplified

One of Professor Samuelson's early articles on the theory of public expenditure[1] contains a diagram that differs from Figure 1 primarily in that we have assumed constant marginal costs (following assumption 6, to be specified below). As Samuelson notes, Pareto optimality exists when the sum of the marginal rates of substitution between the public and private goods equals the marginal cost of the public good in terms of the private good (marginal rate of transformation). Thus if output of the good is Pareto optimal, shares in the benefits from the public good accrue to individuals in proportion to their marginal rates of substitutions or evaluations of the public good in terms of the private good. The question,

[1] Paul A. Samuelson, "Diagrammatic Exposition of a Theory of Public Expenditure," Review of Economics and Statistics, 37 (1955), pp. 350-356.

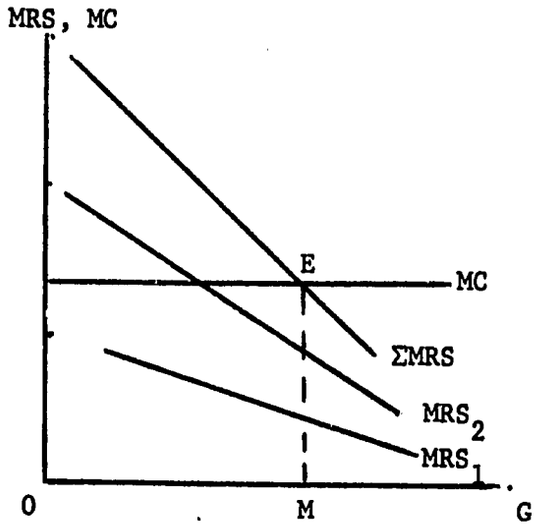

Figure 1

then is how these marginal rates of substitution or evaluation differ with income. Aaron and McGuire's analysis provides an answer if we are willing to accept their assumptions -- especially the assumption that we know how the marginal utility of income is related to income.

Aaron and McGuire make the following assumptions:[1]

Assumption 1: Each household's marginal rate of substitution between public goods and other goods is known, or assumed.

Assumption 2: The total and marginal cost of public and specific goods is known for all relevant outputs of these goods.

Assumption 3: All utility functions are identical.

Assumption 4: All of each public good enters every household's utility function.

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[1] Aaron and McGuire, op. cit., pp. 910-911.

Assumption 5: All households in each income bracket can be represented by the average income level and expenditure mix in that bracket.

Assumption 6: The marginal cost of public goods equals the average cost at the amount supplied.

Assumption 7: The actual output of public and specific goods is allocatively efficient, so that marginal cost equals the sum of marginal rates of substitution ($MC = \Sigma MRS$).

Assumption 8: The utilities of public goods and of other goods are independent.

As Aaron and McGuire note, only the first two assumptions are essential to their analysis, though their conclusions are altered if some of the others are relaxed. For now, we maintain all eight assumptions.

From assumption 7, the Pareto optimality assumption, we know that $\Sigma MRS = MC$, or in the case of a two individual (household) world, that

$$\frac{MU_{G1}}{MU_{Y1}} + \frac{MU_{G2}}{MU_{Y2}} = MC, \tag{1}$$

where MU_G and MU_Y are the marginal utilities of public goods and of private goods (including benefits from specific public services) and the numerical subscripts indicate the individuals in question.[1] Assumption 8, that utilities of public goods and private goods are independent implies that the total utility function for any individual can be written in the following form:

$$U = f(G) + h(Y). \tag{2}$$

[1]There is, of course, no problem in extending the analysis to the case of many households. And as is common in analyses of this type, we ignore problems of preference revelation, which may be required for the attainment of Pareto optimality, but not its definition.

Moreover, assumption 3 states that all utility functions are identical, so that this one function characterizes the utility function of each and every individual.

Differentiating equation (2) for each individual partially with respect to the consumption of the private and public goods, we can determine the implicit values of the marginal utilities in our expression for Pareto optimality, equation (1). The two marginal utilities of private income are simply $MU_{Y1} = h'(Y_1)$ and $MU_{Y2} = h'(Y_2)$. The analogous marginal utilities of consumption of the public good are $MU_{G1} = f'(G_1)$ and $MU_{G2} = f'(G_2)$. But because the same level of a pure public good must be produced for all individuals, we see that these last expressions collapse to

$$MU_{G1} = MU_{G2} = f'(G).$$

Substituting these expressions for marginal utilities into expression (1) we see immediately the Aaron-McGuire result that benefits of pure public goods are distributed in inverse proportion to the marginal utility of private income.

This result seems anomalous in that we may be accustomed to thinking of shares in benefits in public goods as being distributed in direct proportion to the evaluation of the public good in terms of the private good. In the Aaron-McGuire analysis the evaluation of the public good seems not to matter at all! The anomaly is, of course, easily explained, given the assumptions of the analysis. By assumption all individuals have identical separable utility functions for the two (public and private) goods and therefore experience the same marginal utility from the common level of public good provided. Thus it is not the marginal evaluation of the public good, <u>per se</u>, that matters in determining shares in benefits.

Rather it is the marginal utility of the numeraire (private) good to persons at various income levels.[1] If the marginal utility of private income declines with income, allocation of equal amounts of benefits from public goods to each household overstates benefits to low income groups, and if marginal utility fo income declines rapidly enough as income rises, the provision of public goods paid for through a flat-rate income tax actually redistributes income toward upper income groups. As Aaron and McGuire have stressed, "the impact of the budget on income distribution cannot be evaluated unless a utility function is employed, explicitly or implicitly, to estimate public good income."[2] Knowing the correct utility function seems, unfortunately, to be impossible, despite Maital's strong contention that based on three independent estimates we can be sure of the value of the relevant parameter.[3]

Some readers may have noticed the similarity between the Aaron-McGuire theory as explained to this point and the sacrifice version of the ability-to-pay principle of taxation. It can be shown that under the requirement of equal absolute sacrifice, contributions to total tax revenues would be inversely proportional to the marginal utility of income. In the two person case, equal absolute sacrifice requires satisfaction of two conditions:

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[1] Lindahl had quite explicitly recognized this; see Shlomo Maital, "Public Goods and Income Distribution: Some Further Results," Econometrica, 41 (1973), pp. 561-568, esp. p. 567, note 11.

[2] Aaron and McGuire, op. cit., p. 914.

[3] Whereas Aaron and McGuire utilize utility functions in which the marginal utility of income (a) is inversely proportional to income and (b) declines with the square of income, Maital claims that the relevant coefficients on income in the expression for the marginal utility of income is -1.5, midway between the values Aaron and McGuire used for purposes of illustration. Of course, the evidence cited by Maital does not bear upon the important question of whether utility functions are separable.

$$\Delta U_1 = \Delta U_2 = k \tag{3}$$

and

$$\Delta Y_1 + \Delta Y_2 = -T, \tag{4}$$

where T is the total amount of tax revenue to be raised and k is a constant. Equation (3) describes the condition that everyone must experience the same absolute loss of utility and equation (4) the condition that the sum of losses of private income equals the total tax revenue collected. Dividing equation (4) by the corresponding terms in equation (3) yields the following:

$$\frac{\Delta Y_1}{\Delta U_1} + \frac{\Delta Y_2}{\Delta U_2} = -T/k. \tag{5}$$

This can be rewritten in the terminology used above as:

$$\frac{k}{MU_{Y1}} + \frac{k}{MU_{Y2}} = -T. \tag{5a}$$

Thus we have shown that benefit principle taxation to pay for pure public goods requires taxation based on the principle of equal absolute sacrifice! This is, of course, contrary to the usual notion that the sacrifice doctrine is applicable only to the ability-to-pay principle of taxation. A further implication of this demonstration is that we need not devote much effort to determining which utility functions imply benefits which are proportionate to income and which have pro-poor and pro-rich distributional implications. We need only refer to the literature on equal absolute sacrifice.[1] And we can more easily appreciate the difficulties of imple-

[1]For more on the sacrifice version of the ability-to-pay principle, see Musgrave, op. cit., chapter 5, and Charles E. McLure, Jr., "Negative Income Taxation and the Ability to Pay," Rivista di Diritto Finanziario e Scienza delle Finanze, 29 (1970), pp. 594-617. It is small wonder that two of the efforts to estimate the schedule of the marginal utility of income cited by Maital, op. cit., pp. 564-567, were involved with the (actual or ideal) progressivity of the personal income tax.

menting the Aaron-McGuire approach by recalling the well-known obstacles to implementing the equal absolute sacrifice doctrine. But the difficulties are compounded in the present case by the restrictive assumptions underlying the Aaron-McGuire analysis as presented to this point. We turn now to the consideration of some of these complications.

3. The Model Complicated

Aaron and McGuire assert that any of assumptions 3 to 8 could be relaxed without damaging their analysis, if sufficient information is known about the cost and utility functions. In this section we examine briefly the implications of relaxing the assumptions one at a time, leaving to the reader the exercise of determining the implications of relaxing several assumptions simultaneously.

Assumption 3 can be relaxed if we know the utility function for each household or, relying on assumption 5, if we are willing to assume a representative utility function for each income group. No useful purpose seems to be served by rehashing this venerable problem. Rather, we turn briefly to an issue not raised in the Aaron-McGuire analysis.

Aaron and McGuire assume implicitly that the public goods under discussion are indeed "goods" for everyone and "bads" for no one. Thus it is assumed that everyone benefits from the budgetary activity, so that the only question is how to allocate the costs of the shared benefits among households. But if the "good" in question is in fact a "bad" for some persons -- as it would be if it generated disutility for some households, the analysis must be altered somewhat, though not in principle. Figure 2 shows a case in which at the optimal level of output (though not at all levels)

individual 1 receives disutility (MF) from the public good.[1] Thus for Pareto optimality to prevail, the contribution of individual 2 (MD) must be great enough to pay the real costs of producing OM of the good (ME) and compensate individual 1 for the loss of welfare he experiences. But this implies that the question of "who benefits" is more complicated even than it looks.

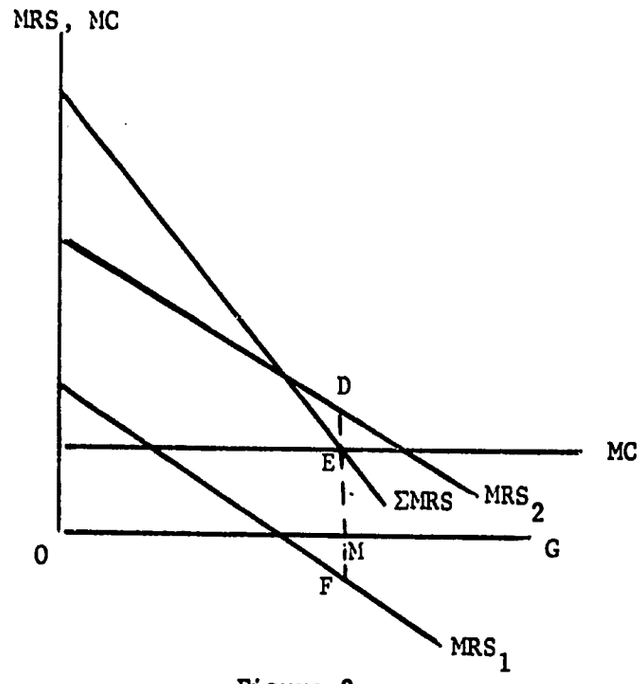

Figure 2

[1]Vito Tanzi, "A Note on Exclusion, Pure Public Goods, and Pareto Optimality," Public Finance, 27 (1972), pp. 75-78, has referred to this as the case of the "forced rider". A public good can have disutility for some households only if, in Tanzi's terminology, non-exclusion is bilateral. That is, not only can beneficiaries not be excluded from benefits, but those who suffer from consuming the good cannot prevent themselves from consuming it.

Such a case is ruled out in the original Aaron-McGuire analysis by assumptions 3, 4, and 8. If one individual experienced disutility, all would, and the good would not be produced in a Pareto optimal situation (unless marginal costs were negative). Of course, if Pareto optimality does not prevail, government activity could entail disutility for all, because of overproduction.

Since there are "negative beneficiaries" we cannot simply allocate the total costs of providing the "service" among households. We must allocate to the income classes containing negative beneficiaries the appropriate income loss. To the classes containing "positive beneficiaries" we must allocate a total amount of benefits equal to the sum of the real cost of providing the service and the loss to negative beneficiaries. This complicates the practical empirical problem facing us, if not the principle.[1] And lest one think it is only an irrelevant theoretical curiosum, he need only reflect upon the problem of allocating the benefits of national defense (offense?) during the Vietnam war.[2] Or, to take less spectacular examples, involving activities providing both specific and public "benefits", we can consider such government projects as fluoridation of water, urban renewal, the construction of a trans-Sierra highway, etc. There is little doubt that some groups would protest vigorously -- and have done so -- the notion that they benefit from such public services.

Assumption 4 is apparently required to assure that we are dealing with "really" pure public goods, since violation of it would seem to imply that the good in question is at least partially specific in that it is consumed by some households but not equally by all. In other words, if this assumption does not hold, the good is specific in that not all households benefit

[1] In principle the existence of negative beneficiaries does not affect the rule for allocating benefits to income classes. Some households simply have negative marginal rates of substitution between public and private goods. Similarly, in principle, no complication is caused by the fact that income classes have both free riders and forced riders; presumably there exists a representative (free of forced) rider.

[2] Of course, if taxes were actually based on voluntary exchange, the problem of under-revelation of preferences would be aggravated by the phenomenon of the "nominal pacifist," the "hawk" who for fiscal purposes says he is a "dove" in order to ride free on the defense expenditures of others -- and be bribed to do so. As noted earlier, this issue is not germane to the present discussion.

from equal amounts of it, but public in that it is "available" to all households, because of non-exclusion. Public goods with geographically limited benefits constitute an important case of the violation of this assumption. Since at the conceptual level this and other cases of violation of this assumption can be handled in a straightforward manner, there is no reason to pursue it further here.

Assumption 6 means that allocation of benefits based on marginal evaluations results in allocation of exactly the total cost of provision of public goods, if output is Pareto optimal. ($\Sigma MRS = MC = AC$) If it is violated, we could not legitimately allocate precisely the total costs among beneficiary groups. If average cost is rising, allocation in accord with marginal evaluations would result in an amount of benefits that exceeds total costs. Conversely, in the decreasing cost case so common in the literature of public finance, this kind of allocation would result in unallocated costs -- costs which would not necessarily represent waste. There seems to be no satisfactory way around this problem, though allocation of costs in proportion to marginal evaluations may be as good as any.[1]

Assumption 7 implies that people get what they want in the collective provision of public goods, no more and no less. Its violation implies that

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[1] In the case of decreasing costs we might be tempted to include infra-marginal benefits, via a measure of consumer surplus. There are at least three objections to this approach, over and above the empirical problems of implementing it. (Note that we must be able to integrate under the marginal utility curve, instead of just knowing its value at various income levels.) First, evaluation of benefits of public goods would not be based on the same criterion as that of private goods. Both Aaron and McGuire (op. cit., p. 909) and Maital (op. cit., p. 562) make this point with regard to excluding consumer surplus from the evaluation of public goods. Second, there is no reason to expect total benefits calculated in this way to just equal total costs. Third, such an approach would do us no good when we turned to the problem of allocating benefits of public goods produced under conditions of increasing costs.

production of public goods has been overextended or has stopped short of the optimal level. In terms of Figure 3, overproduction at level OM' implies that marginal evaluation (equal to OM'E'H') falls short of total costs (OM'F'H). Thus if we were to allocate only the true benefits of this activity, rather than its costs, we would be left with unallocated costs (E'F'H H'). Ideally this excess cost should be allocated to a separate category of "waste," rather than to households.[1] But we need not dwell at length upon the difficulties of determining the magnitude of waste involved in the budget. Such a determination would entail a cost-benefit analysis

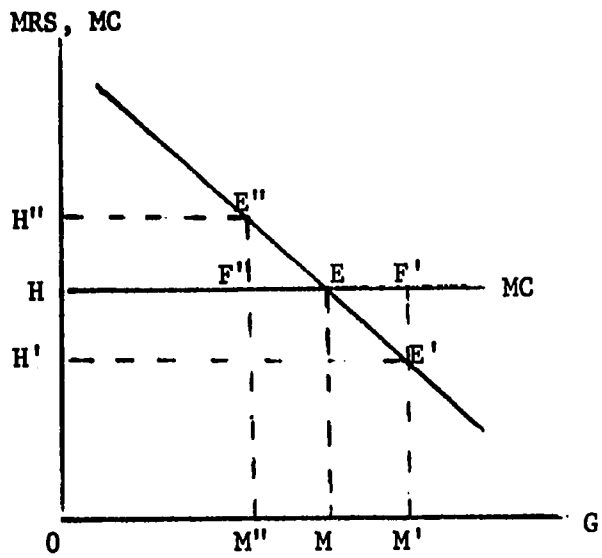

Figure 3

of each public good provided in order to detect and quantify departures from Pareto optimality.

[1]Some readers may object that only the triangle E'F'E really represents waste, because of the infra-marginal benefits of the public good. As before, we have adopted Aaron and McGuire's approach of valuing each unit of public service received at its marginal value, excluding consumer surplus.

The case of underproduction is just the mirror image of overproduction, and involves the same difficulties. In this case the value of output at level OM" is OM"E"H", but the cost is only OM"F"H, leaving a residual of benefits over costs (negative waste?) of HF"E"H".[1] Thus allocation of total costs among household beneficiaries fails to achieve full allocation of benefits.[2] Since in general the economist interested in determining the distributional implications of public spending cannot hope to determine the extent of deviations from Pareto optimality in the provision of public goods, he is almost certainly forced to ignore the deviations.[3] But to the extent that he does so he runs the risk of producing inaccurate results.

Assumption 8 rules out the possibility that certain public goods are strongly substitutable for or complementary to certain private goods. This assumption is clearly untenable for many public expenditures providing specific benefits. (For example, public education is a strong substitute for private education and public highways are strongly complementary with private automobiles and gasoline.) But whether the assumption is reasonable for pure public goods is less obvious, and whether such

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[1]Note that in a real sense output at level OM" involves waste equal to the triangle E E"F", due to the inequality of marginal benefits and marginal costs. The distinction between this measure of waste and the unallocated residual benefit mentioned in the text emphasizes that attribution of benefits is not equivalent to cost-benefit analysis. Similar comments apply to overproduction.

[2]As Aaron and McGuire note, op. cit., p. 911, the same problem arises in national income accounting in cases when market prices do not equal factor prices. In the case of externalities from private action factor costs and market prices do not necessarily measure relevant social costs and benefits, even if they are equal.

[3]There may, of course, be objective evidence of failure to achieve Pareto optimality, say from ex ante cost-benefit analyses or ex post project evaluations. But in general hard evidence may be lacking, especially for expenditures providing pure public goods, and the investigator may be unable

dependence as exists between consumption of various public and private goods is in any way related to income is even less clear. It is simply an extremely difficult empirical question.[1] Thus, even if we accept the first seven of Aaron and McGuire's assumptions, when we come to consider the violation of the eighth, we are brought back to the second fundamental question -- in Aaron and McGuire's words -- of "how the marginal utility of public goods is affected by private income. To the extent that the utility of public goods rises with private income ..., a larger proportion of public goods benefits should be imputed to the wealthy."[2] We know this without reading Aaron and McGuire's article, but now we know it more elegantly.

4. Concluding Remarks

Aaron and McGuire have performed a useful service by specifying precisely and rigorously how one would go about allocating the benefits of public goods among households under ideal conditions. But the violation of Aaron and McGuire's first assumption -- that all marginal rates of substitution between public and private goods are known -- reduces their analysis to an interesting but inconclusive exercise. If the required marginal rates of substitution are not known, the results of the attribution of benefits remains arbitrary, dependent upon the assumed marginal rates of substitution, as Aaron and McGuire clearly recognize. If one

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to evaluate the many pieces of evidence that do exist on individual projects or pieces of the budget.

[1]Violation of assumptions (4) and (8) may occur together. That is, upper income groups may live away from sources of pollution and therefore consume less of the benefits of pollution controls. In this sense income and consumption of this public service are related.

[2]Aaron and McGuire, op. cit., p. 911.

retreats to the very special world of their last six assumptions, the analysis becomes even further divorced from reality, but is at least manageable, given knowledge of the marginal utility of income at various income levels. We have demonstrated that under this rule for the allocation of benefits of public goods, benefit taxation would require adherence to the principle of equal absolute sacrifice. For a marginal utility schedule that has considerable empirical support, benefits of public goods are distributed in a pro-rich pattern. Thus progressive taxation may be required by the benefit principle, as well as the ability-to-pay principle of taxation. But we really do not know much about how fast the marginal utility of income declines as income rises, if indeed it does. Thus, we must conclude that the Aaron-McGuire analysis contributes importantly to our understanding of the problem of allocating benefits of public goods among income groups, but not to its solution.

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