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A theory of jointness and infeasibility of exclusion

Joe Richard Hulett

Iowa State University

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A THEORY OF JOINTNESS AND INFEASIBILITY OF EXCLUSION

by

Joe Richard Hulett

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CHAPTER I. INTRODUCTION

One of the most interesting and important developments in the history of political economy was Adam Smith's (48) discovery that "ideal cooperation" results from each individual's pursuing his own selfish good. As Smith's successors pointed out, however, the validity of this "invisible hand" doctrine requires the satisfaction of certain necessary conditions. These conditions can be expressed generally as the requirement that no discrepancies exist between social wants and private supplies of goods and services.

Monopoly

Abstracting from distributional considerations, the term "ideal cooperation" can be viewed as being synonymous with "Pareto optimality." As is well known by economists, one cause of failure to achieve Pareto optimality is the existence of monopoly elements. Monopolistic firms maximize profits by producing at a level of output for which marginal social benefits (price) are greater than marginal social cost, so that social wants are greater than private supplies.

\footnote{Pareto optimality is defined as a position from which it is impossible, by any reallocation of factors, to improve the welfare of at least individual without harming any other individual.}
Social Cost

Even if the assumption is made, however, that every consumer, every firm, every industry, and every imput market is perfectly competitive, the possibility still remains for divergencies between social wants and private supplies. To illustrate this point, consider the case of pollution. Here, firms may be expected to produce at a level of output for which marginal social benefits are less than marginal social cost, with the result that social wants are less than private supplies. In other words, firms may produce more of a "good" (pollution) than individuals and society desire.

Pollution is one example of a phenomenon which, like monopoly, leads to a divergence between social wants and private supplies. This phenomenon, as will be seen, is associated with the existence of other than fully appropriable private goods. That is, given the assumptions—in a statitical framework—of perfect information, the proper convexities of tastes and technology, and the profit- and utility-maximizing behavior of decision-makers, perfect competition will produce Pareto optimality only if the requirement is met that all goods are fully appropriable private goods.²

²The fundamental characteristic of private goods is that their consumption by one individual precludes the possibility of their consumption, at the same time, by others. Appropriability refers to the effective enforcement of property rights.
Divergencies between private and social net benefits caused by the existence of other than fully appropriable private goods are denoted by terms such as "social cost," "market failure," and "external economies and diseconomies." Unfortunately, these terms do not discriminate between the underlying causes of the divergencies. The purpose of this paper is to identify the causes of "social cost" and to distinguish carefully their allocative implications.

Two causes of social cost

Two fundamentally distinct phenomena representing departures from the concept of appropriable private goods will be examined: "externalities" and "public goods." Externalities are defined as cases of joint supply where all of the products are private goods but where one of the products is characterized by infeasibility of exclusion. Public goods are characterized by "jointness," where jointness exists whenever one individual's consumption of a unit of a good does not preclude the possibility of others' being able simultaneously to consume that same unit.

Externalities

Externalities are shown to exist whenever a good with a nonzero shadow value does not receive its correct price because of the infeasibility of excluding those who do not pay. "Social cost" in the case of externalities is caused by institutional inadequacies, or more specifically, by
the inability to enforce property rights. The point will be emphasized that externalities, unlike public goods, are not characterized by jointness. The inefficiencies associated with the existence of externalities generally can be eliminated through rearrangements of ownership, i.e., through "internalization."

Public goods The failure of competitive markets to achieve Pareto optimality in the provision of public goods is due to individuals lack of incentive to reveal their true preference for goods characterized by jointness. This lack of incentive is owing to consumers' recognition that the possibility exists of consuming units of a public good provided by others. That is, public goods, unlike private goods, may be consumed simultaneously by two or more individuals. Efficiency in the case of public goods is a far more elusive goal than in the case of externalities. As will be seen, neither market nor nonmarket means generally can be relied upon to produce Pareto optimality in the provision of public goods.

In addition to "conventional" public goods, special consideration will be given to cases in which public goods are supplied jointly with one or more private goods. These

3 In the case of externalities, true preferences will be revealed because jointness is lacking, i.e., externalities are a private good phenomenon.
cases will be labeled "merit goods." The basis for a separate and detailed examination of merit goods is that this concept encompasses many real world phenomena--e.g., air and water pollution, education, and health care--that often are viewed mistakenly as involving "externalities."

Summary

In view of the fundamentally distinct allocative problems presented by the existence of externalities and public goods, and recognizing that the two cases may not call for the same "solutions," the two phenomena should not be lumped together under one nondescript term. Unfortunately, much confusion exists because this is exactly what has been done. By distinguishing carefully between the characteristics of externalities and public goods, it is hoped that the following analysis will eliminate some of this confusion.
CHAPTER II. PROBLEMS OF SOCIAL COST

One of the central theorems of modern welfare economics states that under certain assumptions about technology, tastes, and the motivations of decision-makers, the equilibrium conditions of a system of competitive markets correspond exactly to the requirements for Pareto optimality (23, p. 49).\footnote{The existence of firms with technology characterized by increasing returns to scale is not consistent with competitive equilibrium.} The correspondence between competitive equilibrium and Pareto optimality is valid, however, only if all the effects of one economic unit's choices on the well-being of other economic units are transmitted accurately through prices and costs. This will occur only in a private goods economy characterized by universally enforceable property rights. When these requirements are not met, divergencies can exist between private and social costs and/or benefits. Such divergencies are described variously as market failure, external economies and diseconomies, externalities, and social cost (2, 11, 3, 15). What is generally ignored is that, except in certain special cases, situations involving social cost are characterized by the public good phenomenon. Failure to recognize the public good aspect of social cost can lead to confusion and misguided prescriptions for allocative efficiency.
The Two Party Case

Generalizations based on a special case at best may cause misunderstanding and at worst may simply be wrong. Unfortunately, this problem has occurred in economists' treatment of social cost. Most of the contributions to this area of economic theory have dealt explicitly with cases in which the activities of an economic unit affect only one external party, i.e., "two party" cases. A prime example is Coase's "The Problem of Social Cost" (15), an article which, although not known widely, has earned the respect of those to whom it is familiar. Coase dealt exclusively "with those actions of business firms which have harmful effects on others" (15, p. 1). To be more accurate, his analysis was limited to cases in which the actions of business firms harm only one other firm. As will be shown, the analysis of this special case yields results that do not hold, in general, once the two party assumption is relaxed.

Let A be a firm whose activity causes harm to B, and since B can consist of more than one firm and/or individual, let n represent the total number of externally harmed parties. For the special case where n=1, Coase was quite correct in his conclusion that Pareto optimality can be achieved either
by coercing A to compensate B for his losses,\textsuperscript{2} or by free negotiations between A and B. This can be illustrated with Figure 2.1, where the assumption is made that A's marginal gains and B's marginal losses are continuously variable.\textsuperscript{3}

\begin{center}
\begin{tikzpicture}
\begin{axis}[
    xlabel={Scale of A's Activity},
    ylabel={$A$'s marginal gain},
    xmin=0, xmax=10,
    ymin=0, ymax=10,
    xtick={0,5,10},
    ytick={0,5,10},
    grid=both,
    legend pos=north west,
]
\addplot [domain=0:10, samples=100] {10-x};
\addplot [domain=0:10, samples=100] {x};
\addlegendentry{B's marginal loss}
\addlegendentry{A's marginal gain}
\end{axis}
\end{tikzpicture}
\end{center}

\textbf{Figure 2.1. Two party case}

\textsuperscript{2}Although this analysis is presented in terms of A's activities that harm B, the same conclusions would apply to cases where A's activities benefit B.

\textsuperscript{3}If A and B are firms, gain and loss can be measured in money terms as profit differences. If A and B are individuals, their gain or loss could be measured either as the amount of money they would pay, respectively, to undertake and to prevent A's activity, or as the amount of money they would require, respectively, to curtail or to endure A's activity. These two amounts will not be the same, however, unless marginal utility of income is constant; therefore, the assumption of constant marginal utility of income for all individuals will be made throughout this analysis.
If, for some reason, A and B are not free to negotiate, and if A is not held liable for damages to B, then A obviously will produce output OP, thereby maximizing his private gain. Pareto optimality, however, requires the maximization of joint net gain—A's gain less B's loss—and this occurs at output OE. B would be willing to pay up to (III + IV) to secure output OE rather than OP, whereas A would be willing to accept a minimum of (III) to reduce output from OP to OE. Positive gains from trade will accompany a reduction of A's activity level from OP to OE, and if A and B are free to negotiate, their bargaining will produce the Pareto-optimal outcome. The distribution of gains from trade between A and B will depend on their relative bargaining abilities.

If a tax is levied against A to compensate B for damages, A's net gain will be maximized at activity level OE, where he will pay (II) to B, and retain (I). Although the Pareto-opti-

4 The attainment of Pareto optimality through compensation requires in all cases—not only when n=1—that the losses of the harmed parties can be determined without error. The harmed parties, however, will have a strong incentive to overstate the amount of damage they suffer in the hope of securing greater compensation. An external observer may be able to assess accurately the amount of damage if the harmed parties are all firms, but if individuals are also affected this task becomes much more difficult, if not impossible.

5 Plott (35) has stressed the importance of placing the tax on the activity that actually causes the damage. Assume firm A employs a smoke-creating burning process in the manufacture of product X, and that the possibility exists for the firm to alter the ratio of inputs, including the use of the burning process. Then a tax on the production of X rather than specifically on the burning activity may actually result in an increase in smoke production.
output, OE, may be attained either through compensation or free negotiations,\textsuperscript{6} the two approaches can produce very different distributional results. Under compensation, B will receive (II), whereas in the absence of compensation B would be willing to pay up to (III + IV) to secure output OE.\textsuperscript{7} The choice of whether or not to make A legally liable for damage inflicted on B must be based, therefore, on considerations of equity rather than efficiency. In other words, in the special case where \( n=1 \), the "problem of social cost" is not a problem of allocation but of distribution.

\textsuperscript{6}Compensation may, in some instances fail to achieve Pareto optimality by preventing the transfer of resources from inefficient uses. This possibility can be illustrated with a simple example. Assume that firm A's activity damages the crop's grown on a farm firm B, and that A is liable to compensate B for his crop loss. Suppose that in the absence of any production by firm A, firm B would have a net income of $2, derived from crop sales of $12 and expenses of $10. Suppose, further, that firm A's private profit maximizing output causes $3 of crop loss to firm B. When A maximizes profits, therefore, B will still earn annual net income of $2, although his revenue will now consist of $3 compensation from A and $9 in crop sales. Clearly, this is an inefficient outcome. A's costs could be reduced if B would discontinue crop production for any annual payment of less than $3, while B would be willing to retire the land for any payment in excess of $2, his foregone net income. The possibility exists, therefore, for a mutually satisfactory bargain which would entail B's discontinuing crop production. If A is forced to compensate B for crop losses, the optimal solution will be prevented.

\textsuperscript{7}B's private optimum, of course, would require the discontinuation of A's activity, and B would be willing to pay up to (II + III + IV) to secure this result.
Cases Involving Jointness

Although market failure—in an allocative sense—does not occur in the "two party" case, to assume that the same conclusion holds, generally, in cases of social cost involving more than one affected party would be not only heroic, but wrong. The reason, as will be seen, is that when the two party assumption is dropped, elements of the public good phenomenon appear.

Assume, now, that A's activity harms two or more parties, so that B is comprised of \( n > 1 \) parties (firms and/or individuals). Returning to Figure 2.1, the curve of A's marginal gain retains the same interpretation as in the two party case. The curve of B's marginal loss will now be defined as the vertical summation of all the harmed parties' marginal loss curves, since the damage produced by each increment of A's activity is consumed simultaneously by all the externally affected parties.

Pareto optimality, as in the "two party" case, is achieved at OE, and A's private optimum is at OP. A reduction in the scale of A's activity from OP to OE will benefit all the harmed parties simultaneously. The "reduction of harm" accompanying such a cutback is characterized, therefore, by jointness, where jointness is defined as that physical quality of a good which allows its "consumption" by one firm or
individual to cause no reduction in the amount consumed, at the same time, by others. Finally, the "reduction of harm" is a form of public good, since for a good to be defined as "public" requires only that it be characterized by jointness. 8

Two externally affected parties

Consideration first will be given to the possibility of achieving Pareto optimality in cases involving two externally affected parties. In Figure 2.2 the curve "B's summed marginal loss" is derived by adding vertically the marginal loss curves of the two externally affected parties, B1 and B2. The assumption is made that B1 and B2 are harmed identically by A's activity, so the curve "B1's marginal loss" coincides with the curve "B2's marginal loss".

In the absence of either compensation or negotiation between A and the harmed parties, B, the scale of A's activity will be OP in Figure 2.2. A movement from OP toward the Pareto optimal output, OE, benefits the externally affected parties by reducing the amount of harm they suffer. For movements from right to left along the axis of Figure 2.2, therefore, the curve "B's marginal loss" can be viewed, instead, as the curve of B's marginal gain. Similarly, the curve "A's marginal gain" can be viewed, from the standpoint

8The definition of public goods will be examined in greater detail in Chapter IV.
Figure 2.2. Three party case
of the harmed parties, as the marginal cost curve for reductions in harm, e.g., as the marginal cost of reduced air or water pollution. That is to say, in moving from right to left along the axis of Figure 2.2, the curve of A's marginal gain represents the minimum marginal payments required to "bribe" A to reduce its activity level.

Suppose that B₁, acting alone, enters into negotiations with firm A to effect a reduction in the level of A's activity from OP. Acting alone, B₁ will be able to secure a reduction of output to OM. To the left of M, the minimum amount required by A to further reduce output is greater than B₁'s associated reduction of loss. B₁, acting independently, will "supply" PM units of "reduced harm", which then will be available not only to B₁, but also to B₂.⁹ B₁ would be able to supply additional units of "reduced harm" if he were to receive, for each incremental unit to the left of M, a subsidy at least as great as the difference between his marginal loss curve and A's marginal gain curve. A supply curve can be drawn representing the minimum amounts B₁ would require to "produce" more than PM units of "reduced harm". This supply curve, MN, is derived as the difference between A's marginal gain curve and B₁'s marginal loss curve.

For the range of "reduced harm" between M and E, B₂'s marginal losses are greater than B₁'s locus of marginal

---

⁹The roles of B₁ and B₂ could be reversed without altering the outcome.
supply prices, so trade may develop between the two parties. Trading equilibrium occurs at output OE of reduced harm, where $B_2$'s marginal loss curve intersects $B_1$'s supply curve, MN. Output PE of "reduced harm" is identical to A's activity level OE, so the point of trading equilibrium is Pareto-optimal. The point should be emphasized, however, that there exists no assurance that the two parties will reach the optimal point through free negotiations. In "small group" situations such as this the individuals are apt to behave strategically; that is, to bargain in an attempt to secure for themselves differentially favorable terms. The presence of jointness, even in small group situations, very substantially reduces the likelihood of a Pareto-optimal outcome.

More than two externally affected parties

As the number of externally affected parties is increased to three and beyond, the likelihood of achieving Pareto optimality through either market or nonmarket means diminishes.

If $B_2$ is an individual rather than a firm, he will enter into trade only if his utility is increased by doing so. Roberts (36) has pointed out that whether or not $B_2$'s utility will be increased through trading with $B_1$ for additional "reduced harm" cannot be determined a priori. This is a question that can be answered only on the basis of knowledge of the shape of individual $B_2$'s utility surface for income and "reduced harm". By entering into trade, $B_2$ will increase his consumption of "reduced harm", but reduce his money-holdings. Without knowing the shape of the relevant indifference curves, an ex ante determination of whether this will increase or decrease his utility is impossible.
rapidly. When the number of harmed parties is large, individual members of the group, recognizing the jointness characteristic of "reduced harm", rationally will understate their true marginal evaluations for "reduced harm" in the hope that they will be able to secure the benefits of the public good without contributing toward its cost (the amount necessary to bribe A to curtail the scale of his activity). Each harmed party will find it rational to behave in this manner even though the composite result of such individual and independent action will be nonoptimal for all members of the group. This is the "free-rider" problem, and it prevents the attainment of Pareto optimality in the provision of public goods by voluntary financing.

The possibility may exist of excluding from the benefits of "reduced harm" all those who do not contribute toward its provision. This will not assure Pareto optimality, however, because no means exists by which an external observer could determine accurately whether or not each harmed party contributes in accordance with his marginal evaluation. Compounding this problem is the fact that each harmed party will have an incentive to understate deliberately his true marginal evaluation. The relationship of exclusion to public goods is considered further in Chapter IV.

Nonmarket approaches also will fail, in general, to produce Pareto optimality in the large number case. A
suggestion might be made, for example, to form a collective
decision-making unit of all the externally affected parties.
Collective decisions could then be made through some voting
rule, with individual citizen-taxpayers bound by group deci-
sions. The funds necessary to secure a reduction of firm
A's activity to the level OE could be acquired through
taxation. Any voting rule short of unanimity, however, leaves
open the possibility of an allocation of tax shares that is
highly unfavorable to parties outside the winning coaliti-

tion. That is to say, the only voting rule which assures
that no taxpayer suffers a net loss of utility as a result
of a group decision is one which allows every taxpayer the
power of veto over each tax sharing proposal put before the
group. 11

A second nonmarket approach would be to coerce firm A,
through a collective decision, to compensate the externally
harmed parties. The attainment of Pareto optimality by
this means would require an accurate evaluation of the damage
suffered by the harmed parties. Such an evaluation will be
very difficult, if not impossible, especially if the harmed
group includes individuals along with firms.

In moving from cases of divergence between private and
social cost-benefit calculations involving one externally
affected party to cases involving n parties, the analysis
has led to a theory of public goods and jointness. That is, the failure of competitive market equilibrium to produce Pareto optimality in the situations examined thus far is due to the problems associated with jointness. This is not to imply, however, that all situations in which competitive equilibrium fails to produce Pareto optimality are due to the existence of jointness.

Market Failure and Private Goods

Competitive equilibrium may fail to produce Pareto optimality even in an economy characterized by a total lack of jointness and, therefore, public goods. "Market failure" in such cases is due to the existence of externalities. Externalities are defined as cases of Marshallian joint supply\(^{12}\) (25, p. 388) where all of the products are private goods, but at least one of the products is characterized by infeasibility of exclusion.\(^{13}\) Externalities will be produced in the long run only if at some level of output of

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\(^{12}\) Marshallian joint supply, as distinguished from jointness, exists when a single production unit (sheep) supplies two or more products (wool and mutton). Marshallian joint supply involves vertical summation of market demand curves for products, whereas jointness involves the vertical summation of individual demand curves. This distinction is discussed further in Chapter V.

\(^{13}\) Externalities are examined in somewhat greater detail in Chapter III.
the production unit the price(s) of the jointly supplied marketable products are equal to or greater than average cost.

Externalities are inconsistent with Pareto optimality because private goods with non-zero shadow values do not receive their correct price. This occurs because institutional arrangements fail to exclude from the consumption of such goods those parties who do not pay the correct shadow price. Take, for example, the case of the jointly supplied private goods, apple and nectar. Nectar has a positive shadow price since it is an input in honey production. The orchard owner, however, may find it impossible to determine accurately the amounts of nectar gathered by the bees of various honey producers. The beekeepers, themselves, may have no way of determining where the nectar is gathered. If exclusion is not feasible, the ratio of inputs employed in honey production will not be Pareto optimal.\footnote{14}{The absence of Pareto optimality in the apple-nectar-honey example is demonstrated mathematically in Chapter III.}

Increasing the number of potential consumers of a jointly supplied private good characterized by infeasibility of exclusion does not introduce jointness. Nectar is a purely private good regardless of the number of potential consumers. That is, more nectar for one beekeeper necessarily means less nectar for another beekeeper. Externalities cause
market failure because of infeasibility of exclusion, not because of jointness. Exclusion, if it were feasible, would eliminate market failure in the case of externalities, while neither exclusion nor any other institutional arrangement can guarantee Pareto optimality in cases of jointness (public goods).

Summary

A system in competitive equilibrium may fail to satisfy the requirements for Pareto optimality because of the existence of jointness (public goods) and/or jointly supplied private goods characterized by infeasibility of exclusion (externalities). These two problems were distinguished in F. M. Bator's "The Anatomy of Market Failure" (2). Bator, in what may have been an unfortunate choice of terminology, called situations characterized by jointness "public goods externalities", and situations involving jointly supplied private goods characterized by infeasibility of exclusion "ownership externalities." The indiscriminate use of the term "externality", may be somewhat dangerous, because

Bator distinguished a third category of "market failure" which he labeled "technical externalities." This type involves the existence of firms whose technology is such as to render the set of feasible production points nonconvex. In other words, "technical externalities" is synonymous with "increasing returns to scale" or "decreasing cost firms". Since nonconvexity of production sets is inconsistent with competitive equilibrium—although not with Pareto optimality--this problem is not considered in this analysis.
the impression may be created that Pareto optimality can be achieved in all such cases by "internalization", i.e., by merger or some other institutional arrangement. As has been suggested, no such ready-made solution exists in solutions characterized by jointness.
CHAPTER III. EXTERNALITIES

Externalities already have been defined as cases of Marshallian (25, p. 388) joint supply where all the products are private goods, but where at least one of the products is characterized by infeasibility of exclusion. This definition permits a clear distinction to be drawn between cases in which the failure of competitive market outcomes to be Pareto optimal is due to the existence of public goods (jointness), and cases in which the failure is related exclusively to private goods (externalities). This is an important distinction because the possibilities of attaining Pareto optimality are quite different in the two cases. For example, inefficiencies caused by externalities may be eliminated through improved modes of exclusion, whereas even the most highly refined techniques of exclusion cannot fully eliminate inefficiencies associated with jointness.

Externalities and Pareto Optimality

Externalities, as defined above, can be illustrated with a simple example involving the production of apples, nectar, and honey, all of which are private goods. The following assumptions will be made: apple trees produce apples (A) and nectar (N) in a fixed ratio; the production of apples and nectar requires only a single input, labor (L); and honey (H) production requires both labor and nectar. Pareto optimality
requires that

\[ P_A \frac{dA}{dL} + P_N \frac{dN}{dL} = w \]  

(3.1)

\[ P_H \frac{dH}{dL} = w \]  

(3.2)

\[ P_H \frac{dH}{dN} = P_N \]  

(3.3)

where \( P_A, P_H, P_N \), and \( w \) are the prices of apples, honey, nectar, and the wage rate, respectively. An externality exists if the assumption is made that the orchard owner is unable, because of infeasibility of exclusion, to enforce payment for his nectar. If the orchard owner receives no payment for the nectar \( (P_N=0) \), Equation 3.3 will not be satisfied--assuming the price of honey \( (P_H) \) to be positive. Furthermore, the amount of labor employed in orcharding will be less than Pareto-optimal since the private VMP of orchard labor \( (P_A \frac{dA}{dL}) \) is less than its social VMP \( (P_A \frac{dA}{dL} + P_N \frac{dN}{dL}) \).

To reiterate, the failure of competitive markets to achieve Pareto optimality in situations involving externalities is due to a failure of institutional arrangements. The difficulty does not reside in the presence of jointness, since the "unpaid factor," nectar, is explicitly assumed to be a private good. If payment for the unpaid factor could be enforced, the externality would be eliminated.
The term "externality", as it is defined above, applies uniquely to cases in which the nonexclusion characteristic of a jointly supplied private good causes competitive equilibrium not to be Pareto optimal; i.e., causes "market failure". Unfortunately, the term "externality" is also employed in describing not only situations which do not involved "market failure", but situations in which "market failure" may be due to jointness (public goods). Two such uses of the externality notation will be examined: "pecuniary externalities" and "technological externalities." The "pecuniary externality" concept bears no relationship to externalities as defined above, whereas the "technological externality" concept includes both situations characterized by externalities and situations characterized by jointness.

**Pecuniary externalities**

Pecuniary external diseconomies are created when an expansion of the output of a competitive industry causes an increase in the price of one or more of the inputs employed by firms in the industry. Pecuniary external economies are created when an expansion of the output of a competitive industry causes a decrease in the price of one or more of the inputs employed by firms in the industry. In other words, pecuniary external diseconomies are one cause of the positive
slope of the long run supply curves of competitive increasing cost industries, while pecuniary external economies are one cause of the negative slope of the long run supply curves of competitive decreasing cost industries. The point to be made is that pecuniary externalities, by themselves, cause no departure from Pareto optimality.

Marshall (25) and Pigou (34), however, were convinced that increasing cost industries represent a less desirable application of economic resources than do decreasing cost industries. They argued that the equilibrium output of increasing cost industries is greater than required for Pareto optimality, and that a tax should be levied against such industries to bring about the "correct" output. Conversely, it was argued that decreasing cost industries require a subsidy for the attainment of the Pareto optimal output. Both arguments involve fallacious reasoning, and since the two cases are not strictly symmetrical, they will be considered separately.

**Pecuniary external diseconomies** Pigou argued that competitive increasing cost industry output as determined by the intersection of industry demand and supply curves is greater than Pareto optimal because the upward sloping industry supply curve does not account for increases in the price of inframarginal units of factors employed in the industry. In other words, the industry supply curve repre-
sents the increasing cost of marginal input units employed in producing successive increments of output, whereas Pigou asserted that the "correct" supply curve for determining socially optimal industry output should represent the marginal cost of output including the increased value of all inframarginal, as well as marginal, input units. Pigou chose to call this "a curve of marginal supply prices" (34, pp. 172-179).

In arguing that ideal industry output is determined by the intersection of demand and marginal supply price curves, Pigou erred in failing to recognize that the price increases accruing to inframarginal input units as industry output expands are producer's rents, and not, therefore, a true social cost. That is, the marginal social (opportunity) cost of employing resources yielding n units of output is merely the cost of resources required for the n\textsuperscript{th} unit. This cost is expressed by the industry supply curve, not by the curve of marginal supply prices. The latter curve is not a social cost curve because it includes increments to rent. Therefore, the assertion that competitive increasing cost industries produce a greater than Pareto optimal level of output because they generate pecuniary externalities is inaccurate. Although Allyn Young (53) was the first to point this out, he was not successful in articulating the specific nature of the error. The ensuing debate was finally resolved
by Ellis and Fellner (19), who drew heavily from the work of Robertson (37), Sraffa (49), Robinson (38), and Knight (22).

**Pecuniary external economies** The existence of pecuniary external economies necessarily implies, as well, the existence of internal economies; i.e., the existence of firms with negatively sloping long run average cost curves. The existence of pecuniary external diseconomies is inconsistent, therefore, with competitive equilibrium. If, as is likely to occur in the absence of collective action, single firms are able fully to exploit internal economies, then the basis for pecuniary external economies is eliminated and a monopoly problem is created. Ignoring this possibility, however, as long as inputs produced under conditions of increasing returns are sold at their declining marginal cost price, there will be no divergence from the conditions for Pareto optimality.

**Technological externalities**

A second broad category of "externalities" are the so-called "technological externalities." Technological externalities, unlike pecuniary externalities, do not lead, generally, to Pareto optimal competitive market outcomes. The term "technological externality" can apply both to those

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1. The fundamental distinction between "pecuniary externalities" and "technological externalities" first was made clear in Viner's "Cost Curves and Supply Curves" (51).
cases in which market failure is due to the existence of jointly supplied private goods characterized by infeasibility of exclusion (externality), and to cases in which market failure is due to the existence of jointness (public goods). The lumping together of these two fundamentally different phenomena is undesirable because, as has already been pointed out, they represent quite different problems with respect to the attainment of Pareto optimality.

Technological externalities require that

\[(3.4) \quad f^B = f^B(X_1, X_2, \ldots, X_n, Y_1),\]

where \( f^B \) can be viewed either as a utility function or production function of some economic unit \( B; X_1, \ldots, X_n \) are activities under \( B \)'s control; and \( Y_1 \) is under the control of some other economic unit, \( A \). \( Y_1 \) can represent either a consumption or production activity of unit \( A \).

A technological external economy exists when

\[(3.5) \quad \frac{\partial f^B}{\partial y_1} > 0,\]

which means that increases in the scale of \( y_1 \) cause upward shifts of the utility or production function of unit \( B \).

A technological external diseconomy exists when

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2Strictly speaking, the term "technological externality" also encompasses the "two party case" which, as was shown in Chapter II, does not involve a failure of competitive markets to achieve Pareto optimality.
which means that increases in the scale of $y_1$ cause downward shifts of B's utility or production function. ³

If $y_1$ involves the production of a public good, e.g., national defense or water quality, then "market failure" is caused by jointness. If, on the other hand, $y_1$ involves the production of a private good characterized by nonexclusion, e.g., nectar, then "market failure" is the result of externality.

Although many systems have been devised for classifying various types of technological externalities (13, p. 58), they generally do not point out the fundamental distinction between cases characterized by the infeasibility of exclusion of a jointly supplied private good (externality), and cases characterized by jointness. Two notable exceptions, however, are Bator's "The Anatomy of Market Failure" (2), which has already been discussed, and Meade's "External Economies and Diseconomies in a Competitive Situation" (28). Bator explicitly differentiated between externality and jointness as causes of "market failure," whereas Meade's use of examples implied a recognition of these two fundamental cases.

³In referring to shifts in B's utility or production function caused by changes in the scale of $y_1$, the implication is that the axes of the utility or production surface represent only those activities under B's control.
Meade discussed two types of technological externality: "unpaid factors of production," and "creation of atmosphere." The "unpaid factor" case, which he illustrated using the apple-nectar-honey production example, corresponds to the case defined above as "externality."

Meade went on, however, to draw what he viewed as an important distinction between a "factor of production" and a "physical or social atmosphere" as elements affecting the output of a firm or industry. In contrast to a "factor of production", a unit of "atmosphere" is defined to be available simultaneously to more than one producer. Meade based his second category of externality, "creation of atmosphere", on the premise that "the activities of one group of producers may provide an atmosphere which is favorable or unfavorable to the activities of another group of producers" (28, p. 62). As an example of "atmosphere externalities" he constructed a situation in which the afforestation of an area to the leeward of a wheat producing region causes an increase in the availability of rainfall for the wheat growers.

"Atmosphere", as defined by Meade, seems clearly to involve the production of a public good. In his example, the lumber industry can be viewed as supplying a public good--"conditions favorable to the creation of rainfall"--which benefits all wheat growers within a particular region. Even if exclusion of those wheat growers refusing to pay for the "conditions favorable to the creation of rainfall" were possible,
Pareto optimality probably would not be achieved owing to the existence of jointness.

The "creation of atmosphere" category of technological externalities developed by Meade represented a significant departure from the general trend of social cost literature in that it explicitly moved away from the "two party" case which, as has been shown, involves no allocative problems, to the much more interesting and important "many person" case which is a serious obstacle to allocative efficiency. Unfortunately, Meade, along with Coase and others, appears not to have fully appreciated the importance of this distinction.

Summary

Because the two cases present different allocative problems, care should be taken to distinguish between situations in which the failure of competitive market outcomes to be Pareto optimal is due to private good phenomena, and situations in which it is due to the existence of public goods. Defining "externality" as the case of jointly supplied private goods where one of the products is characterized by infeasibility of exclusion allows this distinction to be maintained. The distinction has been clouded, on the other hand, by the indiscriminate use of the term "externality" to apply both to cases which involve no allocative problems ("pecuniary externalities"), and to cases in which inefficiency may be due to the existence of public goods
("technological externalities"). Brief mention should also be made that the reason Buchanan and Stubblebine's "Extensibility" (11) was neglected in the above discussion is that, as will be seen, "Buchanan-Stubblebine externalities" are characterized by jointness, and fit more logically, therefore, in a discussion of public goods.
CHAPTER IV. PUBLIC GOODS

The failure of competitive markets to produce Pareto optimality can be caused by the existence of either public goods or externalities.¹ Since externalities are, by definition, associated exclusively with private goods, the fundamental distinction between public and private goods serves also to distinguish between public goods and externalities; that is, public goods are characterized by jointness whereas private goods, and therefore externalities, are not. Jointness exists whenever one individual's consumption of a unit of some public good does not preclude the possibility of others' being able simultaneously to consume that same unit. Any good characterized by jointness is, by definition, a public good, regardless of whether or not it is also characterized by impossibility of exclusion. Because of jointness, individuals have no incentive to reveal their true preferences for public goods, and this prevents the attainment of Pareto optimality.

Theoretical Forerunners

The origins of modern public good theory are found in writings on taxation dating back to the Middle Ages. Two

¹The assumption will continue to be made that competitive equilibrium is a realizable goal. This implies, in turn, an assumption of universal non-increasing returns to scale (convex production sets).
distinct principles or approaches to taxation have developed through the years: the benefit approach and the ability-to-pay approach. The benefit approach says that individual tax obligations should be based on the benefits received from the enjoyment of public services, while the ability-to-pay approach says that individual tax obligations should be based on capacity to pay. Both the benefit approach and the ability-to-pay approach were viewed by the writers of the period between the seventeenth and twentieth centuries as standards of equity, not of efficiency (30, p. 63). The protection of property rights was regarded during this period as the basis for the existence of governments, and since the amount of protection an individual received was viewed as being in direct proportion to his wealth, "fairness" was thought to require a distribution of tax shares according to wealth.²

²Adherence to the view that governments are formed to protect property rights and that individuals benefit from this protection in proportion to their wealth allows a synthesis of the benefit and ability-to-pay approaches to taxation. This is reflected in Adam Smith's first maxim of taxation (48, p. 310).

"The subjects of every state ought to contribute toward the support of government, as nearly as possible, in proportion to their respective abilities; that is, in proportion to the revenue they enjoy under the protection of the state."
Toward the end of the nineteenth century, however, a fundamental change of emphasis occurred. Triggered by advances in subjective value theory, the benefit approach to taxation came to be viewed not primarily as a standard of equity, but as a requirement for allocative efficiency. The benefit approach, unlike the ability-to-pay approach, requires that the tax and expenditure sides of the budget be considered simultaneously. Pantaleoni (32), who was one of the first economists to become concerned with problems of allocative efficiency in the public sector, argued that only the benefit approach, by requiring the simultaneous consideration of tax and expenditure sides of the budget, provides a basis for determining whether or not the benefits of collective spending are worth the cost in terms of reduced private spending.

Accompanying the increased concern for efficiency of resource allocation in the public sector, public goods came to be recognized as a distinct phenomenon, differentiated from private goods by the characteristic of jointness. Since most programs of collective taxation and expenditure involve the supplying of public goods, attention came to be focused (1) on the requirements for allocative efficiency in public goods provision, and (2) on the ability of institutions to satisfy these requirements. These two questions now will be
considered in that same order.

Optimality in the Provision of Public Goods

Partial equilibrium approach

Public goods efficiency will be discussed first in a partial equilibrium framework and then in a general equilibrium framework. While the general equilibrium approach is superior on grounds of realism and completeness, the partial equilibrium approach does allow certain points to be emphasized. The partial equilibrium analysis will draw heavily on the work of Bowen (5) and Lindahl (24), who developed independently what has come to be known as the "voluntary exchange" theory of public goods. The Bowen and Lindahl contributions are flawed by their erroneous assertions that Pareto optimality in the provision of public goods will be produced by the free expression of individual preferences. Nevertheless, their analytical tools--especially the individual "demand" curves for public goods developed by Bowen--are very useful in discussing certain aspects of the allocation of resources to public goods.

Individual "demand" curves for public goods should not be viewed simply as public good analogues of individual demand curves for private goods. In the case of public goods, unlike private goods, the possibility exists for consumption of units of a good purchased (and consumed) by someone else.
An individual's "demand" curve (curve of marginal evaluations) for a public good does not represent the prices that he necessarily must pay to consume various quantities of the good, since the possibility exists, even if the price is not paid, that the public good will be supplied by others. The individual will have a strong incentive to conceal his preferences for a public good, since if he is successful in avoiding payment his utility clearly will be increased. Whereas an individual demand curve for a private good represents the quantities which a "rational" individual will purchase in response to various given prices, the individual "demand" curve for a public good does not represent the prices that a "rational" individual will pay for a good the quantity of which he is unable independently to determine. To give emphasis to these fundamental differences between the two cases, individual "demand" curves for public goods will be referred to as "pseudo-demand" curves.

In Figure 4.1 the quantity of a public good, $X_p$, is measured along the horizontal axis, while price, measured as the ratio of the prices of $X_p$ and a private numeraire good, $X_r$, is measured along the vertical axis. The assumption is made that the numeraire good has constant marginal utility for all individuals, so that no income-effect shifts in the

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3 A rational individual is defined as one who attempts to maximize his utility, subject to a budget constraint.
curves occur. The curves \( D_A \) and \( D_B \) are the pseudo-demand curves for the public good of individuals A and B, respectively. Since each point on a pseudo-demand curve represents an equality of \( P_p/P_r \) and marginal rate of substitution between \( X_p \) and \( X_r \) (MRS), the curves \( D_A \) and \( D_B \) could be labeled \( MRS_A \) and \( MRS_B \), respectively.\(^4\) The curve \( D_T (\Sigma MRS) \) is the vertical summation of curves \( D_A (MRS_A) \) and \( D_B (MRS_B) \), and represents the total pseudo demand of the two individuals for the public good. Vertical summation is required because any given quantity of the public good is consumed simultaneously by both individuals. The marginal cost of producing the public good is.

\(^4\)This is the notation generally employed by Samuelson (41, 46).
good—in terms of the private good—is assumed to be constant and is represented by the curve MC.

The Pareto-optimal output of the public good is OP, where the individuals' summed marginal evaluations (pseudo-demands) equal marginal cost; or, using different terminology, OP is Pareto optimal because it represents equality between the individuals' summed marginal rates of substitution (EMRS) and marginal cost.\(^5\) If output OP could be attained, the way in which the cost of that output is distributed between the two individuals is a question of equity rather than efficiency under the assumptions of this model. That is, since the assumption has been made that the marginal utility of the numeraire good is constant for both individuals, redistributions of income (in terms of the numeraire good) do not change the optimal output. If the endowments prior to the production of the public good are judged to be "just" in the light of the full set of production possibilities, then a distribution of tax shares on the basis of individual marginal evaluations (MRS) will not disrupt that welfare judgement. If, on the other hand, the initial endowments are judged to be "unjust", the individual tax shares could be set so that the post-tax distribution of income is "just".

\(^5\)That OP is, in fact, Pareto optimal will become clearer when the problem is analyzed in a general equilibrium framework.
The point is, however, that the Pareto optimal point \( OP \) probably will not be attained, since individuals will have no incentive to reveal their true marginal evaluations for the public good. Furthermore, there exists no means by which an external observer can determine an individual's true marginal evaluation.\(^6\) In a small group situation such as the one depicted, each individual sees the possibility of consuming the public good at the others' expense, and the employment of strategy probably will prevent the attainment of Pareto optimality. According to Buchanan, (6, p. 84).

"In small group situations, each potential trader is motivated to behave strategically, to bargain, in an attempt to secure differentially favorable terms. Here the individual will find it to his advantage to conceal his true preferences and to give false signals about these preferences to his opponents-partners."

If, on the other hand, the number of consumers of the public good is "large", individuals will not expect to influence the decisions of other individuals, and "strategic" behavior will not be employed. Instead, each person is apt to adjust his own behavior to the behavior of "others" taken as a group, without the expectation that the behavior of the "group" may change. Each individual, operating on the belief that whether or not he contributes to the provision of the

\(^6\)The ability of an external party to determine individual marginal evaluations will be discussed below at greater length.
public good will have little effect on the total supply, will have no incentive to reveal his true preferences. This is the "free-rider" problem. Of course, the aggregate effect of such behavior will be significant.\footnote{Olson (31) has developed a very thorough analysis of group size.}

While the partial equilibrium approach to optimality in the provision of public goods is informative and in no sense wrong, the assumption of constant marginal utility of the numeraire good is very restrictive. In moving to a general equilibrium framework this assumption can be dropped, which will permit an explicit recognition of the relationship between equity and efficiency in public goods supply.

**Diagrammatic general equilibrium approach**

The development in a general equilibrium framework of the conditions for Pareto optimality in the provision of a public good allows the restrictive assumption of constant marginal utility of the numeraire good to be dropped and thereby permits an explicit recognition of the interrelationship between distribution and allocative efficiency. The following analysis will draw heavily on the work of P. A. Samuelson (41), who was the first to develop a general equilibrium theory of public goods. The arguments will be presented first in diagrammatic form, and then mathematically.
The diagrammatic approach is presented in Figures 4.2, 4.3, and 4.4.

Figure 4.2, the transformation function for private and public goods, relates the maximum quantities of private and public goods that can be produced with existing technology and a fixed resource endowment. The combination of private and public goods that is actually produced will depend on consumer preferences and the distribution of income. Assume initially that only private goods are produced and that they are distributed between two individuals, A and B, in a manner that is considered "just". In Figure 4.2 the maximum possible output of private goods is seen to be OE, and the initial endowments are assumed to be OC for individual A (Figure 4.3) and OD for individual B (Figure 4.4), where OC + OD = OE. Assume further that both individual A's and individual B's factor incomes do not change with changes in the output mix of private and public goods.

Public goods are assumed to be produced only if at least one of the individual's welfare can be improved (while causing no harm to the other). Figures 4.3 and 4.4 depict a situation in which the production of public goods will cause a movement toward the utility-possibility frontier. In Figure 4.3, individual A's consumption of private goods is measured along the horizontal axis and his consumption of public goods along the vertical axis. The curve IC shows the
Figure 4.2. Transformation function

Figure 4.3. Individual A's indifference map

Figure 4.4. Individual B's indifference map
combinations of private and public goods which bring individual A the same level of satisfaction as does his initial endowment of private goods, OC. By assumption, the production of public goods cannot be undertaken unless individual A is able to maintain a level of utility at least as great as represented by $i^C$. Although A is indifferent among the combinations on $i^C$, individual B will not share this indifference since A's location along $i^C$ will determine B's consumption of both private and public goods. Individual B's consumption of public goods will, at any point along FE in Figure 4.2, be the same as A's, and B's consumption of private goods will equal the difference between the total production of private goods, again as shown on FE, and A's private goods consumption.

Curve HD in Figure 4.4 depicts B's consumption of private and public goods as A moves along his indifference curve $i^C$. If, for example, A is located at U on $i^C$, then his consumption of private goods is OM, B's consumption of private goods is OQ ($OX-OM=OQ$), and both A and B consume OJ of public goods. Of all the combinations along HD, individual B prefers T, since that is the point at which his indifference curve $i^C$ is tangent to his locus of consumption possibilities as determined by A's movement along $i^C$. Therefore, T is a Pareto-optimal point, given the initial allocation of private goods to A and B, and given the specific cost sharing scheme.
represented by A's movement along $i_C$ and B's corresponding movement along HD.

At each level of provision of public goods as measured along the vertical axes in Figures 4.2, 4.3, and 4.4, the slope of HD is, by construction, equal to the difference between the slope of the transformation function (MRT) and the slope of A's indifference curve, $i_C$ (MRS$^A$). At the Pareto-optimal point $T$, the slope of HD is also equal to the slope of B's indifference curve, $i_B'$. Pareto-optimality, therefore, is characterized by equality of the marginal rate of transformation between public and private goods and the sum of individual A's and B's marginal rates of substitution between public and private goods. In other words, Pareto optimality requires that $\text{MRT} = \text{MRS}_A + \text{MRS}_B$. Returning briefly to Figure 4.1, point $P$ can be seen to satisfy the requirement of equality between summed marginal rates of substitution and the marginal rate of transformation (marginal cost of the public good in terms of the numeraire good), so the pseudo-equilibrium output, OP, is Pareto-optimal.

An infinite number of additional Pareto-optimal points could be derived in Figures 4.2, 4.3 and 4.4. One example is point $S$ in Figure 4.3. Point $S$ results from the same initial income distribution as point $T$, but it involves a cost-sharing scheme in which B moves along his indifference curve $i_D'$, and A moves along the corresponding consumption possibility curve $GC$. 
All Pareto-optimal points such as S and T can be transferred to a utility possibility frontier on which the efficient combinations are represented in terms of ordinal indices of A's and B's utility. The curve P in Figure 4.5 represents such a locus of Pareto-optimal points.

![Utility frontier of Pareto-optimal efficiency points and its tangency to highest attainable social welfare contour](image)

A "best" point from among the infinity of Pareto-optimal points can be chosen only with the use of a social welfare function which permits the evaluation of the social gain or loss resulting when A's position is improved at the cost of B's, or vice versa. The contours labeled $w'$, $w''$, and $w'''$ are derived from a social welfare function, and the best point, B, is determined by the tangency of the utility possibility
frontier and the iso-social welfare contour, \( w' \). The point B, it should be noted, can be reached through an infinite number of combinations of initial endowments and cost-sharing plans, all of which allow \( MRT = \Sigma MRS \). \(^8\)

**Mathematical general equilibrium approach**

The general equilibrium approach can also be developed mathematically. For example, the Lagrangian approach can be followed to maximize A's utility subject to (1) a fixed resource endowment, and (2) a constant level of utility for B. The ordinal utility functions of two individuals, A and B, can be represented as

\[
(4.1) \quad U^A = U^A(X^A, X_p)
\]

\[
(4.2) \quad U^B = U^B(X^B, X_p)
\]

where

- \( U^A \) = an ordinal index of A's utility,
- \( U^B \) = an ordinal index of B's utility,
- \( X^A \) = the amount of private good \( X_r \) consumed by individual A,
- \( X^B \) = the amount of private good \( X_r \) consumed by individual B.

\(^8\)McGuire and Aaron (26) have pointed out very clearly the relationship between equity and efficiency in the provision of public goods.
\[ X^B_r = \text{the amount of private good } X^r \text{ consumed by individual B, and} \]
\[ X_p = \text{the amount of public good consumed by both A and B.} \]

A transformation function, relating the combinations of \( X^A_r, X^B_r, \) and \( X^2 \) that can be produced with the economy's fixed resource endowment, \( \bar{R} \), is represented as

\[ (4.3) \quad F(X^A_r, X^B_r, X_p) = \bar{R}. \]

The Lagrangian expression to be maximized is

\[ (4.4) \quad \phi = U^A(X^A_r, X_p) - \lambda [F(X^A_r, X^B_r, X_p) - \bar{R}] - \mu [U^B(X^B_r, X_p) - \bar{U}^B], \]

where \( \lambda \) and \( \mu \) are Lagrangian multipliers, \( \bar{R} \) is the fixed resource endowment, and \( \bar{U}^B \) is a fixed level of B's (ordinal) utility.

By first differentiating 4.4 with respect to \( X^A_r, X^B_r, \) and \( X_p \), then setting the partial derivatives equal to zero, and finally eliminating the Lagrangian multipliers from the resulting system, the optimality condition 4.5 is
obtained.\(^9\)

\[
\frac{\partial U^A}{\partial x^A_r} + \frac{\partial U^B}{\partial x^B_r} = \frac{\partial F}{\partial x_r}
\]

Equation 4.5 shows that in order to maximize A's utility subject to a fixed level of B's utility, a combination of public and private goods should be produced such that A's and B's summed marginal rates of substitution equal the marginal rate of transformation between public and private goods. This is the same first order marginal condition that is satisfied by every Pareto-optimal point along the curve \(P\) in Figure 4.5. The second order conditions require

\(^9\) The steps of the derivation of Equation 4.5 are as follows.

1). Differentiate Equation 4.4 with respect to \(x^A_r, x^B_r\), and \(x^P\), and set the partial derivatives equal to zero.

\[
a) \frac{\partial \phi}{\partial x^A_r} = \frac{\partial U^A}{\partial x^A_r} - \lambda \frac{\partial F}{\partial x^A_r} = 0, \quad b) \frac{\partial \phi}{\partial x^B_r} = \lambda \frac{\partial F}{\partial x^B_r} + \mu \frac{\partial U^B}{\partial x^B_r} = 0
\]

\[
c) \frac{\partial \phi}{\partial x^P} = \frac{\partial U^A}{\partial x^P} - \lambda \frac{\partial F}{\partial x^P} - \mu \frac{\partial U^B}{\partial x^P} = 0
\]

2). Divide (c) by (b).

\[
d) \frac{-\lambda \frac{\partial F}{\partial x^A_r}}{\frac{\partial U^A}{\partial x^A_r}} + \frac{\frac{\partial F}{\partial x^B_r}}{\frac{\partial U^B}{\partial x^B_r}} = \frac{\lambda \frac{\partial U^B}{\partial x^B_r}}{\frac{\partial U^B}{\partial x^B_r}}
\]

3). Divide (d) by (a) to get Equation 4.5.
the proper convexities of the utility and transformation functions.

In dealing with private goods, the marginal conditions for Pareto optimality require equality between all individual marginal rates of substitution and the marginal rate of transformation. Letting $x_a^g$ and $x_b^g$ represent the amounts of a second private good consumed, respectively, by individuals A and B, the Pareto optimality conditions for private goods are the following:

$$\frac{\partial U_a^A}{\partial x_a^A} = \frac{\partial U_b^B}{\partial x_b^B} = \frac{\partial F}{\partial x_g^g}$$

(4.6)

The optimality requirements of Equations 4.5 and 4.6 can be generalized to the case of $s$ individuals ($i = 1, \ldots, s$), $n$ private goods ($j = 1, \ldots, n$), and $m$ public goods ($k = 1, \ldots, m$). The total quantity consumed of any private good, $x_j$, equals the summation of the quantities consumed by the $s$ individuals, so that $x_j = \sum_{i=1}^{s} x_{i,j}^i$. The total quantity consumed of any public good, $x_{n+k}$, equals the quantity consumed
by each individual, so that \( X_{n+k}^i = X_{n+k}^i \). Each individual is assumed to possess a continuous, convex, ordinal utility function of the form \( U^i = U^i(X^i_1, \ldots, X^i_{n+m}) \). The production possibility function is also assumed to be convex and continuous and is represented as \( F(X^1, \ldots, X^m) = 0 \), where production inputs are "negative" goods. The procedure will be followed of writing the partial derivative of any function with respect to its \( j \)th argument by a \( j \) subscript; e.g.,

\[
U^i_j = \frac{\partial U^i}{\partial X^i_j}.
\]

The equilibrium conditions represented in Equations 4.5 and 4.6 for the two-person, two-good case can be rewritten in generalized form, respectively, as

\[
(4.7) \quad \sum_{i=1}^{s} \frac{U^i_{n+k}}{U^i_1} = \frac{F_{n+k}}{F_1} \quad (i = 1, \ldots, s; k = 1, \ldots, m)
\]

\[
(4.8) \quad \frac{U^i_j}{U^i_1} = \frac{F_j}{F_1} \quad (i = 1, \ldots, s; j = 2, \ldots, n)
\]

The infinity of Pareto-optimal solutions to Equations 4.7

\[10\] This equation, together with the requirement that each individual's consumption of such a good leads to no substitution from any other individual's consumption of that good, constitute Samuelson's 1954 definition of a public good (45). He acknowledged recently that this definition has caused a certain amount of confusion (46, p. 108). Some economists apparently took the requirement of "equal consumption" to mean that each person's marginal evaluation for a public good must be the same, which, of course, is not the case. A particular good might be liked by some people and disliked by others.
and 4.8 can be represented on an ordinal utility possibility frontier. To determine which point on the frontier is socially most desirable requires a social welfare function, which can be represented as

\[(4.9) \quad w = w(U_1, \ldots, U_s)\]

where \(U_j > 0\). One more equilibrium condition must be added, therefore, to determine the best of all possible Pareto-optimal configurations. This condition can be written as

\[(4.10) \quad \frac{w_i U_i^i}{w_1 U_1} = 1 \quad (i = 2, \ldots, s).\]

Equation 4.10 is simply the mathematical expression of the tangency between \(w"\) and \(P\) represented in Figure 4.5.

Equation 4.8, representing the optimality conditions for private goods, will be satisfied automatically in a competitive economy characterized by the proper convexities and an absence of externalities. On the other hand, Equation 4.7, representing the optimality conditions for public goods, will not be satisfied by a system of competitive markets. The reason, of course, is that consumers have no incentive to reveal their true preferences for goods characterized by jointness.
Voting and public goods optimality

Because of the strong tendency for individuals not to reveal their true preferences for public goods, such goods generally are provided (financed) collectively. The argument has been made that public goods theory is, in effect, an economic theory of government (9, p. 25). Unfortunately, however, the collective provision of public goods does not insure Pareto-optimal outcomes.

The "free-rider" problem characteristic of large group situations involving public goods can be eliminated only when each individual is made aware that his own behavior does affect the total outcome. Wicksell (52) concluded that, ideally, all group decisions on public goods provision should be made under a unanimity voting rule. Strict unanimity can be viewed as effectively transforming the case involving large numbers of consumers of a public good into a small number case involving just two parties; the individual, and the "rest of the group". Although the "free-rider" problem is eliminated, it may be replaced with problems of strategy inherent in two-person games.

The problems of strategy associated with unanimity voting will be minimized if the individual taxpayer believes that his acceptance or rejection of a specific cost-sharing proposal will have little or no effect on the order of presentation of subsequent proposals. That is, if a person
is confronted with a proposal which provides him with a net gain, but at the same time he feels that a subsequent proposal may be even more to his advantage, then he will veto the current proposal. If he feels, on the other hand, that subsequent proposals are just as likely to be unfavorable as favorable, then he may abandon strategy and vote "yes" on the current proposal.

Most individuals confronted with a unanimity voting rule might be expected to vote in favor of cost-sharing proposals which present them with net benefits (a "taxpayer's surplus") and which allocate the remainder of the costs in a manner considered "just". Expecting every individual to behave in such a manner probably would be unrealistic, however. There would seem to be a strong likelihood that for nearly every proposal submitted to the group at least one individual, employing strategic behavior, will cast a negative vote and defeat the proposal. Unanimity thus presents essentially the same problem as that when coercion is lacking completely; few, if any, public goods will be provided. Although the unanimous approval of a proposal represents, by definition, a movement toward Pareto optimality, the problem is to secure the passage of any cost-sharing proposal put before the group.

Wicksell recognized this shortcoming of unanimity voting and was led to modify his scheme by substituting "relative unanimity" for strict unanimity. He viewed "relative unanimity" as a five-sixths majority, although the basis of this particu-
lar choice is unclear. Majority voting schemes, however, are subject to the problem of cyclical majorities (the "paradox of voting") discussed in the pioneering works of Dodgson (17), Black (4), and Arrow (1). Strictly speaking, there is no assurance that any voting rule short of strict unanimity will produce, in the absence of side payments, a movement toward Pareto optimality. The point already has been made, however, that the employment of strategy will serve to prevent the passage of measures under unanimity. The conclusion must be reached that voting, like voluntarism, generally will not produce Pareto optimality in the provision of public goods.

Nonexclusion and Public Goods

Jointness has been defined above as the fundamental characteristic of public goods. That is, a public good has been defined as any good characterized by jointness. Confusion exists, however, as to whether or not nonexclusion from consumption should be viewed as a second essential characteristic.

Buchanan and Tullock (12, p. 152) point out that in the absence of side payments or vote trading each person's vote carries the same weight. This prevents the individual voter from being able to express his intensity of preference for or against a particular measure. Permitting those citizens who feel strongly about an issue to compensate those whose opinion is only feebly held can result in gains for both groups.
of public goods. There are those who argue that nonexclusion is a fundamental characteristic of public goods (30, pp. 7-8; 21; 31, p. 14; 18, pp. 248-249), that where exclusion is possible services do not fall under the strict definition of a public good (33, p. 121), and/or that the distinctive feature of public goods is that exclusion costs something (28, p. 69). Some refer to nonexclusion as a characteristic of those public goods which must be provided publicly, often without commenting on whether or not nonexclusion is a fundamental characteristic of public goods however provided (7, p. 18; 10, pp. 17-19; 30, p. 126; 47, pp. 66-74). In the following argument, however, support is given to the view expressed above that if a good is characterized by jointness it is a public good, regardless of whether or not exclusion is possible.

To demonstrate that exclusion does not eliminates the problems inherent in the provision of public goods, assume a situation in which a perfectly discriminating monopolist has a franchise for supplying a public good, and that this monopolist has the ability to exclude from consumption all those who do not pay. Some economists have argued that Pareto optimality will result from such a situation, but this erroneous assertion is based on a misunderstanding of the role of exclusion as it relates to public goods.

Suppose the monopolist were able to bargain on an all-
or-nothing basis with each potential consumer of the public good. Unless, however, he possesses the power to know what is in peoples' minds, he will find it quite impossible to determine individual consumers' true marginal evaluations for the public good. Consumers will understate their true preferences, for although the monopolist is able to exclude people who do not pay, he has no way to prevent people from paying less than their true marginal evaluations and becoming, in a sense, free-riders. Since the monopolist has no way to determine and collect consumers' true marginal evaluations, the public good will not be provided in the optimal quantity as determined by equality between summed marginal evaluations and marginal cost. Exclusion, therefore, even in the hands of a perfectly discriminating monopolist cannot change the fundamental nature of public goods; namely, that situations involving jointness inevitably cause consumers to understate their true preferences.

Furthermore, cases exist in which exclusion, even if feasible, would be undesirable. Take, for example, the case of an uncrowded bridge. Construction of a toll booth and the levying of charges against those crossing the bridge would be a simple matter. This would, however, produce a non-optimal state of the world since the marginal cost of an additional bridge crossing is zero (ignoring maintenance costs). Charging a toll would clearly violate the P=MC requirement
for Pareto optimality. If the bridge does become crowded to the point where an incremental crossing reduces the speed with which all those using the bridge at a point in time are able to cross, then the marginal cost of crossings is greater than zero and tolls may be required to efficiently allocate the use of this facility. The ability to exclude will facilitate this task, but it certainly does not convert the public good into a private good. The charging of tolls does not alter the fact, that given certain assumptions about capacity and the units of time employed, one individual's crossing the bridge does not preclude the possibility of others' being able to cross at the same time.

The point should be emphasized that the question of tolls and bridge crossings is concerned with allocating the use of the public good, which is distinct from the problem of providing the bridge. Optimal provision of the bridge will require, as in the case of all public goods, the impossible task of determining accurately individual marginal evaluations.

Two Interpretations of "Increasing Returns"

The notion of "increasing returns" can be given two different interpretations in the analysis of public goods, and considerable confusion has been caused by the indiscriminate
use of the term. The dual meaning of increasing returns is unique to public goods, and it arises because the output of public goods can be measured either in terms of production units or consumption units. In the case of private goods, on the other hand, production units and consumption units are, by definition, identical.

To illustrate this problem suppose that there exists an island community with a single television station, and that the station's signals can be picked up by anyone on the island with a TV set. The television signals are a public good since they can be consumed by more than one person at the same time. Television output could be measured either as (1) viewer-hours per day, or (2) hours per day of transmission. The first measure of output is in terms of consumption units while the second is in terms of production units.

Television costs can be examined either in terms of

12 A certain amount of confusion has been caused by the use of the term "increasing returns" in the following sequence of articles: Samuelson's "Aspects of Public Expenditure Theories" (39), Samuelson's "Public Goods and Subscription TV: Correction of the Record" (44), Buchanan's "Public Goods in Theory and Practice: A Note on the Miniasian-Samuelson Discussion" (8), and Samuelson's "Pitfalls in the Analysis of Public Goods" (43). In the first two articles Samuelson seems to refer to increasing returns in terms of consumption units. Buchanan then clearly employs the notion of increasing returns in terms of production units. In Samuelson's final article of the sequence the reader is left with little choice but to conclude that Buchanan's use of the term has been adopted.
viewer-hours per day or hours per day of transmission. In
terms of the former, television transmission is clearly a
case of increasing returns. Once a capacity to transmit
signals is established, the marginal cost of increasing
the number of viewer-hours per day is zero. This follows
from the definition of public goods, which implies increasing
returns in terms of consumption units.

The phenomenon of increasing returns in terms of
production units, on the other hand, is due to factors that
bear no relationship to the publicness or privateness of
the good. *A priori* predictions of increasing returns based
on the consumption characteristics of goods are not possible
if output is measured in terms of production units. In terms
of the island television station, whether television output,
measured as hours per day of transmission, displays increas­
ing, decreasing, or constant returns is an empirical question
that is not related to the fact that the signals happen to
be a public good.

An analytical bond does exist, however, between public
goods and increasing returns in terms of production units.
When increasing returns of this type exists, perfect compe­
tition will not be self-sustaining since firms that equate
price and marginal cost will suffer continuing losses. If
these firms are limited to marginal cost pricing, a
subsidy will be required to ensure their continued
existence.\textsuperscript{13} The determination of whether or not a particular decreasing cost firm should receive a subsidy must take into account the total benefits to society generated by that firm's activity. This requires the proper weighting and summation of inframarginal consumers' and producers' surpluses, a task not unlike the determination of individual marginal evaluations for public goods.

**Buchanan-Stubblebine "Externalities"**

Although the title of Buchanan and Stubblebine's "Externality" (11) suggests that this well-known article should be included in a discussion of externalities, this was not done because Buchanan and Stubblebine's "externalities" are characterized by jointness and involve, therefore, public goods. Buchanan and Stubblebine set out in their article to "clarify the notion of externality by defining it rigorously and precisely" (11, p. 1). In defining externalities "rigorously and precisely" they actually have defined public goods,\textsuperscript{14} including cases where public goods are supplied jointly along with one or more private goods.

\textsuperscript{13}If the firms are not constrained to marginal cost pricing, monopoly likely will result.

\textsuperscript{14}The authors, themselves, comment, "...our analysis allows the whole treatment of externalities to encompass the consideration of purely collective goods" (11, p. 383).
Cases will be considered where an activity $y_1$, under the control of individual 1 affects the utility of one or more additional individuals. An "externality" in the Buchanan-Stubblebine sense exists, in its simplest form, when an activity $y_1$, under the control of individual 1 affects the utility of one other party, individual 2.

The utility function of individual 2 is defined as

$$U^2 = U^2(x_1, \ldots, x_n, y_1)$$

where $x_1, \ldots, x_n$ are activities under his own control. A "marginal externality" exists when $U_1^2 \neq 0$, where $U_1^2$ is the partial derivative of individual 2's utility function with respect to $y_1$. If, through a change in the scale of $y_1$ individual 2's welfare can be improved without harming individual 1, then the "marginal externality" qualifies as a "Pareto-relevant externality". A marginal externality is Pareto-relevant when

$$\frac{U_1^2}{U_2} > \left( \frac{U_1^2}{U_2} - \frac{F_1}{F_2} \right)$$

and when $\frac{U_1^2}{U_2} < 0$, and

$$\frac{U_1^2}{U_2} < \left( \frac{U_1^2}{U_2} - \frac{F_1}{F_2} \right)$$

when $\frac{U_1^2}{U_2} > 0$.

---

15 The same conclusions would be reached if, instead, cases were considered in which the activity $y_1$ affects the production functions of one or more additional firms.
In Equations 4.12 and 4.13 the terms $X_r$ and $Y_r$ denote, respectively, the activities of individuals 1 and 2 in "consuming" some numeraire commodity. The ratio $F^1_1/F^1_r$ is individual 1's marginal rate of substitution between $Y_1$ and $Y_r$ in consumption or exchange, i.e., the marginal cost of performing activity $Y_1$ in terms of $Y_r$. Equation 4.12 represents a "Pareto-relevant external diseconomy" while Equation 4.13 represents a "Pareto-relevant external economy."

Pareto optimality requires that the inequalities in Equations 4.12 and 4.13 be converted to equalities by an adjustment in the scale of $Y_1$. In the case of Pareto-relevant external diseconomies this will require that the scale of $Y_1$ be reduced, while Pareto-relevant external economies call for an expansion of $Y_1$. Pareto equilibrium is defined to exist when

\[
(4.14) \quad (-) \frac{U^2}{U^2_r} = \frac{U^1}{U^1_r} - \frac{F^1}{F^1_r} \quad \text{and when } \frac{U^1}{U^1_r} < 0, \quad \text{and}
\]

\[
(4.15) \quad \frac{U^2}{U^2_r} = (-) \frac{U^1}{U^1_r} - \frac{F^1}{F^1_r} \quad \text{when } \frac{U^1}{U^1_r} > 0.
\]

Rearrangement of the terms in either Equation 4.14 or 4.15 yields the requirement for Pareto optimality

\[
(4.16) \quad \frac{U^2}{U^2_r} + \frac{U^1}{U^1_r} = \frac{F^1}{F^1_r}.
\]
Equation 4.16 indicates that for Pareto optimality the sum of the two individuals' marginal rates of substitution, or marginal evaluations for \( y_1 \), must equal the marginal cost of \( y_1 \) in terms of \( y_r \). The similarity between Equation 4.16 and the equation for optimality in the provision of public goods is clear. Equation 4.16 can be generalized simply by dropping the assumption that only one external party is affected by \( y_1 \), and replacing it with the assumption that \( s-1 \) individuals in addition to individual 1 are affected. The first-order condition for Pareto-optimality then becomes

\[
\sum_{i=1}^{S} \frac{U_i}{U_r} = \frac{F_i}{F_r}
\]

which is identical to Equation 4.7, the first order condition for Pareto optimality in the provision of public goods.

The basis for the summation of individual marginal rates of substitution (vertical summation of pseudo-demand curves) in the case of Pareto-relevant externalities is the existence of two closely related phenomena: (1) Individual 1's activity, \( y_1 \), simultaneously affects one or more other individuals, and (2) the affected individuals are not able to determine independently the quantities they consume of the good (or "bad"). In other words, Pareto-relevant externalities are characterized by the allocative problem inevitably associated with jointness; namely, that neither market nor non-market means
can be relied upon to automatically generate Pareto optimality.

The similarities between public goods and Pareto-relevant externalities are clear: a Pareto-relevant externality exists when a public good is provided in an amount that is not Pareto optimal. The argument might be made, however, that this interpretation overlooks an important distinction between the two concepts based on the fact that Pareto-relevant externalities can involve not only public goods produced on their own merit, but also public goods that are supplied jointly as a "by-product" in the provision of private goods. Careful evaluation of these two cases reveals that this "distinction" is, in terms of outcomes, more apparent than real.

Consider first the case where an individual, firm, or government provides a public good singly, i.e., not as a joint output in the production of a private good. The quantity provided of the public good probably will be non-optimal owing to the phenomenon of nonrevealed preferences. This creates a Pareto-relevant externality. An optimizing individual or firm may expand output to the point where private marginal evaluation equals marginal cost, but this will not be socially optimal if other parties are affected by the activity. Notice in Equations 4.12 and 4.13 that when individual 1 has achieved utility-maximizing equilibrium so that the terms in parentheses cancel, there will still be a Pareto-relevant externality.
Pareto-relevant externalities may also exist in cases where one or more public goods are supplied jointly in the production of a private good. These cases, characterized both by Marshallian joint supply and by jointness, will be called "merit goods". The failure to attain Pareto optimality in the provision of merit goods is owing not to the existence of joint supply, but to the fact that one of the jointly supplied products happens to be a public good. Because merit goods are of considerable importance—examples involve air and water pollution, education, and health care—but appear to be poorly understood, they will be analyzed in considerable detail in the next chapter.

Summary

The fundamental distinction between externalities and public goods is that public goods (including Buchanan-Stubblebine type "externalities") are characterized by jointness. In situations involving jointness, consumers have no incentive to reveal their true preferences because the possibility exists of consuming units of a good provided and consumed simultaneously by others. Because of jointness, neither market nor nonmarket means generally will achieve Pareto optimality in the provision of public goods. This is true regardless of the possibility or impossibility of
exclusion, or of whether or not a good is characterized by joint supply as well as jointness.
CHAPTER V. MERIT GOODS

Merit goods are defined as cases of joint supply where at least one of the jointly supplied products is a public good. Thus, merit goods are characterized both by joint supply and by jointness. The existence of merit goods causes a failure of competitive market outcomes to be Pareto optimal; the basis for this "market failure" is made clear by distinguishing carefully between "joint supply" and "jointness".

"Joint Supply" and "Jointness"

The standard case of joint supply is that in which two or more tradeable private goods are provided from the same production unit, e.g., wool and mutton are supplied jointly from sheep. Jointness, on the other hand, occurs when a single (public) good may be consumed by more than one individual at a time. Confusion between joint supply and jointness has arisen because both involve the vertical summation

Musgrave (30, p. 13) has defined "merit wants" as those wants "considered so meritorious that their satisfaction is provided for through the public budget, over and above what is provided for through the market and paid for by private buyers." This definition includes not only the concept of merit goods, but also extends to cases in which underconsumption of certain goods results from consumer ignorance or irrationality. If the usual assumptions of perfect information and consumer rationality are made, however, the noneconomic moralist and elitist overtones are stripped from the merit want concept and what remains is the concept of merit goods as defined here.
of demand curves (pseudo-demand curves in the case of jointness). Overshadowing this apparent similarity are fundamental differences, however.

**Jointly supplied private goods**

The market demand curve for sheep is derived by adding vertically (with proper adjustments for units of measurement) the market demand curves for wool and mutton. Because wool and mutton are private goods, their market demand curves are derived by summing horizontally the individual demand curves for wool and mutton, respectively. This is illustrated graphically in Figure 5.1, with the aid of the following assumptions: (1) mutton and wool are produced in constant proportions, (2) sheep are produced at constant cost, and (3) a numeraire private good, $r$, has constant marginal utility for each consumer.
Equilibrium is at point E, where the price of sheep equals the summed prices of wool and mutton.

Jointness

Jointness, by definition, involves public goods. The total pseudo-demand curve for a public good, such as hours of television transmission, is derived by vertical summation of individual pseudo-demand curves. This is depicted graphically in Figure 5.2 with the following assumptions: (1) television signals are produced at constant cost, and (2) a numeraire good has constant marginal utility for both individuals.
Equilibrium is at point E where the summed marginal evaluations of individuals 1 and 2 equal the marginal cost of supplying TV signals.

**Fundamental distinctions**

Joint supply is characterized by vertical summation of market demand curves for different products, whereas jointness is characterized by vertical summation of individual pseudo-demand curves for a single public good. Furthermore, the pseudo-demand curves for the public good are not true demand curves. Increasing the number of consumers of the public good accentuates the problem of non-revealed preferences, while
increasing the number of consumers of mutton and wool leads to a convergence in the usual fashion to the conditions of perfect competition. As Samuelson (40) has pointed out, increasing the number of consumers of a public good only makes attainment of Pareto optimality less likely, whereas increasing the number of sellers and buyers of jointly supplied private goods such as wool and mutton increases the relevance of supply-demand relations.

**Merit goods and "market failure"**

Failure to achieve Pareto optimality in the provision of merit goods is due, clearly, to the jointness characteristic of the public good, and has nothing to do with the fact that the public good is supplied jointly with a private good. Situations such as air and water pollution—which involve the provision of merit goods—sometimes are characterized mistakenly as externalities. The danger in calling merit goods "externalities" is that the term "externality" may, for some, carry the implication that Pareto optimality can be achieved by "internalization", i.e., by effectively combining the acting and affected parties into a single decision-making unit. Internalization cannot prevent, however, the understating of marginal evaluations on the part of consumers of public goods, and will not assure Pareto
optimality in the provision of merit goods.\textsuperscript{2} The allocative problems associated with the provision of merit goods will be considered further through a discussion of two examples; a manufacturing process that causes water pollution, and education.

Water Pollution

Assume that a paper manufacturing firm employs a process which causes large amounts of effluent to be discharged into a stream adjacent to its plant. Suppose, further, that the pollution of the stream reduces its value for downstream recreation. In addition to the private good, paper\textsuperscript{3} the firm's activity produces a reduction of water quality which harms all downstream recreational water users. Water quality exhibits jointness because it can be "consumed" at the same time by two or more individuals, whether they be fishermen, swimmers, or boating enthusiasts. Since jointness

\textsuperscript{2}A possible exception could arise in the event that all the consumers of the public good component are firms, not individuals. Internalization could then take the form of a merger of all firms under a single management unit, in which case the maximization of joint profits would produce a Pareto-optimal outcome. In the more likely case that some of the consumers of the public good are individuals, joint profit and utility maximization loses its operational significance, since it would require the specification of a group utility function.

\textsuperscript{3}"Paper" is a rather broad term encompassing many distinct commodities, and this example would be more realistic if a specific paper product, say facial tissues, were employed as the private good. For simplicity's sake, however, the term "paper" will be retained.
is the fundamental characteristic of public goods, water quality is, by definition, a public good. The firm is engaged, therefore, in the production of a merit good since a unit of output supplies jointly (1) a private good, paper, and (2) a public good, reduced water quality.

Mathematical exposition of the problem

If the firm's activity reduces the water quality "consumed" by s individuals, the harmed parties' ordinal utility functions can be written as

\( U^i = U^i(x^i_1, \ldots, x^i_p, x^i_q) \) \( (i = 1, \ldots, s) \)

where \( (x^i_1, \ldots, x^i_p) \) are activities under individual i's control, with \( x^i_p \) designated as i's consumption of paper; and \( x^i_q \) is the water quality variable which is under the paper manufacturer's control. The transformation possibilities faced by the firm can be summarized as

\( F = F(x_1, \ldots, x_p, x_q) \)

where inputs are included as activities along with output.

Using the subscript \( r \) to designate a numeraire commodity and adopting the convention of writing the partial derivative of a function with respect to its \( j^{th} \) argument by a \( j \) subscript, the first order condition for Pareto optimality in the level of the firm's activity is
In Equation 5.3, \( \frac{U_i}{U_r} \) is individual i's marginal rate of substitution between the numeraire commodity, \( r \), and paper. In competitive equilibrium this ratio must be the same for all consumers and must equal the marginal cost, in terms of \( r \), of paper production. The term \( \sum_{i=1}^{s} \frac{U_i}{U_r} \) is the summation of marginal rates of substitution between water quality, \( q \), and the numeraire commodity for all those affected by the firm's water pollution. Since water quality is a public good, Pareto optimality requires that the summed marginal rates of substitution (individual marginal evaluations for water quality in terms of \( r \)) equal the marginal cost of producing (reduced) water quality which, since water pollution is a by-product of paper production, is the marginal cost of paper production. The right hand side of Equation 5.3 is the marginal rate of transformation between paper and the numeraire commodity, and can be interpreted as the marginal cost of producing paper in terms of \( r \). Summarizing, Equation 5.3 gives the first order marginal conditions for Pareto optimality in a case of Marshallian joint supply where one of the jointly supplied products happens to be a public good.
Diagrammatic exposition of the problem

To depict graphically the above-described problem, the additional assumptions will be made (1) that paper and (reduced) water quality are produced in a constant ratio, and (2) that the numeraire good has constant marginal utility for all the harmed parties. The diagrams will be kept relatively simple by assuming the existence of only three individuals affected by changes in water quality.

In Figure 5.3, $D_p$ is the demand curve faced by the firm for its primary output, paper, with paper production measured along the horizontal axis in units of reduced water quality. $D_p$ is horizontal since, by assumption, the market for paper is perfectly competitive. The curves $D_q^1$, $D_q^2$, and $D_q^3$ represent the pseudo-demands for water quality of individuals 1, 2, and 3, respectively. The vertical summation of $D_q^1$, $D_q^2$, and $D_q^3$ yields $D_q'$, the total pseudo-demand curve for reduced water quality. $D_q^1$, $D_q^2$, $D_q^3$, and, consequently, $D_q'$, lie below the horizontal axis since water quality diminishes for movements from left to right along that axis, and the three individuals receive negative marginal benefits from increasingly polluted water. Total demand for the firm's jointly supplied products, paper and reduced water quality, is derived by vertically summing $D_p$ and $D_q$, yielding the curve $(D_p + D_q)$. Note that the vertical summation of $D_q^1$, $D_q^2$, and $D_q^3$ is justified on the basis that water quality is a public good consumed in the same amount by all three individuals,
Figure 5.3. Conditions for optimality in the provision of water pollution
whereas the vertical summation of \( D_p \) and \( D_q \) and \( D_{p+q} \) is required because paper and reduced water quality are Marshallian joint products. 4

The Pareto-optimal level of the firm's activity, measured as output OE of reduced water quality, is determined by the intersection of marginal cost, \( MC \), marginal cost, \( MC_1 \), and \( (D_p + D_q) \). Output OE is Pareto optimal because only at that point do the sum of marginal benefits of the harmed parties plus the equilibrium price of paper \( (P_p/P_r) \) equal the marginal cost of production.

Approaches to optimality

Although output OE is Pareto optimal, it will not, in general, be attained through either market or non-market forces. The reason is, of course, that water quality is a public good and, as was shown in Chapter 4, Pareto efficiency is a very elusive goal where public goods are concerned. Actual output will be greater than OE, the firm's private profit maximizing output being OF, being OF. Although for any output greater than OE the possibility exists of increasing the welfare of some individuals while harming no one, there is no guarantee that these "gains from trade" will be fully realized due to the problems of strategic behavior associated with it.

4 The market demand curve for paper, on the other hand, is derived by the horizontal summation of individual demand (not pseudo-demand) curves.
with the provision of public goods in small group situations.

**Voluntary action** If the market system is relied upon to produce efficiency in resource use, a reduction of the paper manufacturer's output from the private profit maximizing output, OF, toward the Pareto-optimal output OE, will be accomplished only to the extent that recreational water users are able and, more importantly, willing to bribe the firm to limit its scale of activity. The problem with this procedure will obviously be to secure contributions from the harmed individuals. The firm will require, for each decrement of paper output, a payment at least as great as the difference between the price of paper, \( P^p \), and marginal cost, \( MC \). As a group, the harmed individuals *could* pay for each decrement of paper output an amount equal to their summed marginal evaluations for improved water quality. They *will not* pay this amount, however, since each individual will be motivated to understate his true marginal evaluation in the belief that by so doing he will be able to consume units of improved water quality provided by others. This phenomenon will be more pronounced the larger the number of harmed individuals. Although each individual's actions may produce a negligible effect on the ultimate outcome, the collectivity of individual actions will be significant.
The market system may succeed, nevertheless, in bringing about some reduction of the firm's output from the level OF. The reason is that for the initial decrements of output the summed marginal evaluations of the harmed parties for improved water quality is substantially greater than the difference between \( P \) and MC. In fact, a single individual might realize an increase in welfare by negotiating independently for a reduction in paper output. If individual 1, whose pseudo-demand curve for water quality is represented by \( D_q^1 \) in Figure 5.3, acts alone to bribe the firm to reduce its output, the maximum possible reduction of output would be to level OC.\(^5\) At output OC the maximum amount individual 1 could pay for an increment of water quality (a decrement of water pollution) is equal to the minimum amount the firm would be willing to accept. Whether or not individual 1 will realize a gain in welfare by his independent action depends on his ability to bargain with the firm over the range of output between OF and OC. In order to bribe the firm to reduce its output below the level OC, individual 1 will have to secure the cooperation of one or more other harmed individuals, and this will lead to problems of strategic behavior and, as the number of parties to the

\(^5\) Either individual 2 or individual 3, acting independently on the basis of individual marginal evaluations, could afford to secure a somewhat greater reduction of the firm's output than can individual 1.
bargain increases, to free-riders.

**Collective bribery** Various forms of political "internalization" are often proposed as means by which to overcome the obvious shortcomings of reliance on the market system and voluntarism in situations such as the one being explored.\(^6\) One possible form of nonmarket solution that might be suggested would be to create a governmental unit comprised of all the harmed parties and to endow that unit with the authority to bind each individual to collective decisions made through the application of a voting rule. Unfortunately, as was shown in Chapter IV, no voting rule short of full unanimity can be expected to produce, in the absence of side payments, Pareto-optimal outcomes. Unanimity, while eliminating the free-rider problem, possesses the disadvantage that for large groups the passage of any measure becomes virtually impossible. The passage under less than unanimity of a proposal for levying a tax against harmed parties for the purpose of generating revenue with which to bribe (subsidize) the firm to reduce its output could very easily result in some individuals' welfare being less than if they were to continue to endure the pre-tax water pollution. That is, the

\(^6\) Internalization in the form of an actual merger of the firm and the harmed individuals into a single decision making unit is not a relevant alternative in the case being examined because the maximization of joint profits and welfare is not an operational concept as is the maximization of joint profits in the case of a merger involving only firms.
members of the winning coalition could exploit those outside the coalition. A unanimity voting rule would prevent winners from exploiting losers, but the likelihood of being able to put together a tax proposal that would meet with everyone's approval would be very small, especially if individuals vote strategically.  

Compensation An alternative nonmarket approach would be to tax the paper manufacturer and compensate the harmed individuals. Ideally, the firm should pay a tax on each unit of output equal to the corresponding summed marginal evaluations of the harmed individuals, with the proceeds of the tax going to the harmed individuals. To achieve Pareto optimality through this procedure would require an accurate evaluation of the harm to recreational water users for every level of paper production. Unfortunately, no method exists by which an external observer could determine accurately the pseudo-demands of the harmed parties. In this case the affected individuals will be motivated to overstate the amount of harm they suffer from water pollution in the hope that they will receive compensation in excess of their true marginal  

7 Under a unanimity voting rule an individual might be led to vote against a proposal favorable to him if he feels that a subsequent proposal will be even more favorable.  

8 To repeat a point made in Chapter II, Pareto optimality is achieved by maximizing the firm's gain less the harmed individual's loss, and not, generally, by maximizing the firm's gain less the firm's tax less the harmed individuals' loss.
evaluations. Accurate determination of the total pseudo demand curve, \( D^* \), in Figure 5.1, while necessary for the attainment of Pareto optimality through a tax-subsidy plan, will not be possible.

**Direct controls** Perhaps the most straightforward nonmarket approach to this water quality problem would be to charge a government agency with the responsibility and power for determining the optimal level of paper production and, therefore, water pollution. However, such a plan obviously suffers from the same shortcoming as those considered above; namely, that since water quality is a public good, individual marginal evaluations will not be revealed and cannot be determined otherwise. The government agency will be unable, therefore, to dictate a Pareto-optimal solution.

**Evaluation of the alternatives** Since none of the above-mentioned approaches, either market or nonmarket, can guarantee Pareto optimality, the question should be asked whether, on an *a priori* basis, there is reason to expect any one of the approaches to provide a closer approximation to the ideal solution than the others. The answer to this question is that while none of the approaches appears to be superior to all the rest, the market approach, i.e., solution by voluntary action, will probably produce a less desirable outcome than the nonmarket approaches. The reason is that the market approach must rely for its success on the inde-
pendent actions of one or at most a few individuals in bribing the firm to reduce its output and thereby increase the level of water quality.

The remaining harmed individuals become free-riders. The extent by which one, two, or three individuals can bring about a reduction of water pollution depends on their individual and summed marginal evaluations for water quality. The greater the ratio of their summed marginal evaluations to the summed marginal evaluations of all harmed individuals, the closer will the market solution approach Pareto optimality. Therefore, unless one or a few individuals suffer a disproportionately large share of the harm from reduced water quality, the market approach will not be expected to produce a close approximation to the ideal solution. The larger the number of harmed individuals, the less desirable will be the market solution, in general, relative to the nonmarket approaches.

The discussion of the various approaches to the provision of a merit good has been conducted, thus far, under the assumption that efficiency is a function only of the level of output. Two additional factors, however, should be mentioned. The first is that the market and various nonmarket mechanisms will themselves require different amounts of resources. Nonmarket solutions require the formation and maintenance of governmental units and therefore require a
greater devotion of resources than the market solution. This may partially or wholly offset any advantage the nonmarket approaches may have in moving the output of the mixed good closer to optimum. A second factor which must be considered is that there may exist more than one technology for the production of paper. That is, methods may exist which are less efficient in terms of paper manufacture but which cause a lesser amount of water pollution. The problem then becomes to determine, by the most efficient method, the optimal combination of paper output and technology. The point to be made is that the application of too narrow a view of efficiency may lead to the adoption of inferior solutions.

Education

Most forms of education produce two categories of benefits; (1) the "private" benefits which accrue to the student and/or his family, and (2) the "external" benefits which accrue to members of society outside the student's family. The most obvious and most easily measured private benefits

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9In discussing education it is necessary, particularly when dealing with the elementary and secondary levels, to adopt the student's family rather than the individual student as the basic decision-making unit. The reason for this is twofold. First, the young student does not possess enough information to behave "rationally" with respect to his own education, and secondly, the young student is incapable of financing any part of his education.
of education are the increased productivity and earnings of the educated. Other private benefits, while difficult to quantify, are, nevertheless, important. For example, the mothers of school age children receive the benefit of child care services which may allow them to seek employment or to engage in other activities. Additional education can provide an individual with greater satisfaction in later years of past and continuing exposure to new ideas and cultural opportunities (16, p. 6). Members of the present and future family of the educated individual may benefit by virtue of informal education and improved intellectual environment in the home. These and other private benefits of education are actually a form of private good, since, by definition, they can be "consumed" only by the student and/or his family.

The consumption of educational services produces, in addition to private benefits, several types of external benefits which, by definition, affect the utility of individuals outside the student's family. For example, an individual's education may increase not only his own productivity, but the productivity of others, as well. In modern, industrialized economies, production requires the close coordination and cooperation of many individuals, so that one worker's productivity affects the productivity of many other workers. External benefits in the form of reduced expenditures for crime prevention and welfare may result from increasing the
productivity of the members of families with very low incomes. Further, education improves the functioning of a political democracy by promoting minimum standards of citizenship along with equality of opportunity. Friedman makes this point in his comment "...the gain from the education of a child accrues not only to the child or to his parents but to other members of society; the education of my child contributes to other people's welfare by promoting a stable and democratic society" (20, p. 12).

The various external benefits of education possess one characteristic in common; viz, they all exhibit jointness. That is to say, the external benefits generated by one individual's consumption of educational services may affect the utilities of two or more additional individuals at the same time. Since jointness is the one characteristic that distinguishes public from private goods, the external benefits of education are, by definition, public goods.

A production unit of education, say a student-year, is a merit good since it supplies jointly (in the Marshallian sense) both private goods (private benefits) and public goods (external benefits). As with other merit goods, neither market nor nonmarket means can be relied upon, in general, to produce Pareto optimality in the provision of educational benefits. This is owing not to the Marshallian joint supply characteristic, but to the fact that certain of the jointly
supplied educational benefits are public goods.

**Conditions for Pareto optimality in the consumption of educational services**

Figure 5.4 represents graphically the demands for the educational benefits provided by family 1's consumption of educational services, while Figure 5.5 represents the demands for the educational benefits provided by family 2's consumption of educational services. The curve $D^1_p$ in Figure 5.4 represents family 1's private demand for its own children's education, and the curve $D^1_E$ represents the (vertically) summed pseudo-demands of all those who receive the external benefits generated by the education of family 1's children. Curve $D^1_T$ represents the total demand for the education of family 1's children and is derived by summing vertically the curves $D^1_p$ and $D^1_E$. Note that vertical summation in the case of curve $D^1_E$ is required because the external benefits of the education of family 1's children are a public good, while the vertical summation of $D^1_p$ and $D^1_E$ to get $D^1_T$ is required because the private benefits and external benefits generated by the education of family 1's children are Marshallian joint products. The marginal cost of educating family 1's children is assumed to be constant and is represented by curve $MC$. The curves $D^2_p$, $D^2_E$, and $D^2_T$, in

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10 The marginal utility of a numeraire private good is assumed to be constant for all individuals.
Figure 5.5 are the corresponding demands for the education of family 2's children, and MC is the (constant) marginal cost of providing this education. Costs per student-year of educating the children of families 1 and 2 are assumed to be identical.

The socially optimum consumption of education by the children of family 1 is $Q^1_0$ student years, where marginal cost equals the price $(P^1_p/P^1_r)$ family 1 is willing to pay for their own children's education plus the summed marginal evaluations of the recipients of the external benefits of these same children's education. The amount $P^1_E/P^1_r$ is the "subsidy" per student-year of education that is required for the attainment of Pareto optimality. In the absence of any subsidy, family 1 would achieve its private optimum at $Q^1_p$ student-years of education, which represents underconsumption from the social point of view.11 The optimum output, $Q^1_0$, probably will not be achieved, however, because the external benefits are a public good and the "consumers" of this public good, like the consumers of other public goods, will have no incentive to reveal their true marginal evaluations.

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11 If family 1 privately consumes $Q^1_p$ student-years of education, a movement from $Q^1_p$ to $Q^1_0$ will not, necessarily, be Pareto optimal. A tax levied on the recipients of the external benefits to finance a movement from $Q^1_p$ to $Q^1_0$ may very well harm some of the taxpayers. Depending on the distribution of tax shares, an individual taxpayer may find himself on a lower level of utility when $Q^1_0$ of education is consumed by the children of family 1 than when $Q^1_p$ is consumed and there is no tax.
Figure 5.4. Family 1's consumption of education.

Figure 5.5. Family 2's consumption of education.
tions. Competitive markets cannot be expected, therefore, to yield the ideal subsidy, \( \frac{P^1}{P_r} \). Neither will taxation of the recipients of the external benefits necessarily produce Pareto optimality, since it is impossible for an observer external to the affected individuals to determine accurately either their individual or summed pseudo demands, and thus to determine the optimum tax levy.

For family 2's children, the socially optimum consumption of education is \( Q_o^2 \) student-years. There is no basis within the framework of this analysis to suppose that \( Q_o^1 \) will equal \( Q_o^2 \), even if the assumption is made that the two families have the same number of children and that their age distributions are identical. If the analysis is limited to elementary education, then the inequality of \( Q_o^1 \) and \( Q_o^2 \) is inconsistent with the practice of requiring every child to consume eight years of education. If, on the other hand, the analysis includes secondary education and the various forms of higher education, then this result is entirely consistent with what occurs in actual practice.

**Financing of education**

Because, as has been argued, a production unit of education is a merit good, then education should be financed by a combination of tuition and tax revenues. Buchanan calls this "mixed financing" (10, p. 23). The allocation of costs between tuition and tax revenues will depend, ideally, on the
ratio of private benefits to external benefits. This ratio will vary considerably between different educational levels. While the ratio of private benefits to external benefits is probably quite low for elementary and secondary education, it would seem to be highest for vocational and certain types of professional training. This would help to explain why public elementary and secondary education in this country is financed exclusively by tax revenues. That is, the total pseudo-demand curve for the external benefits of a single child's consumption of education may be highly inelastic in the range of twelve student-years, thus reflecting taxpayer's belief that twelve years of formal schooling is a minimum requirement for the exercise of responsible citizenship in a political democracy. Further, since the property tax is virtually earmarked for education, families can be expected to acquiesce in the level of property taxes up to the point where the marginal tax cost equals the marginal private benefits from the education of their own children.

**Determining the optimal curriculum**

Up to this point, curriculum has been one of the things impounded in *ceteris paribus*. Clearly, however, curriculum plays an important role in determining the ratio of private benefits to external benefits generated by any child's education. In extending the analysis to include curriculum variability, optimality requires the proper quality as well as quantity of education for each family's children. The
necessary conditions for optimality in curriculum choice must be satisfied along with the necessary conditions for optimality in each family's consumption of educational services.

The problem of optimum curriculum choice for a single student is conceptualized in Figure 5.6. Private benefits are measured along the vertical axis, external benefits along the horizontal axis. The assumption is made that the student's curriculum can be varied so as to produce any ratio of private to external benefits.

\[ \text{Figure 5.6. Optimal curriculum} \]

\[ ^{12}\text{Buchanan (7, p. 404), refers to this problem as one of determining the "externality mix."} \]
The curves $C_1$ and $C_2$ are iso-cost curves which are derived by mapping onto the surface of Figure 5.6 the contour lines from the appropriate total cost surface. Curve $C_2$ represents a greater total outlay for the student's education than does curve $C_1$. In order to select the optimal point (optimal curriculum) on each iso-cost curve, it is necessary to introduce a social welfare function which includes among its arguments the public and external benefits of education. The curves $W_1$ and $W_2$ are contours from such a function, each curve representing a constant level of social welfare. These may be called iso-benefit curves, and curve $W_2$ represents a higher level of benefits than does curve $W_1$.

The optimal mix of private and external benefits for each level of total cost is determined by the tangency of iso-cost and iso-benefit contours. The locus of all such tangency points for an individual student constitutes the optimal path of that student's education. In Figure 5.6, curve $L$ is the optimal curriculum locus. The optimal point along the optimal curriculum locus is determined by the equality of marginal cost and the summed marginal evaluations of the recipients of the private and external benefits. As has been pointed out repeatedly, this point will be achieved only if all the affected individuals reveal their true marginal evaluations for the educational benefits. Unfortunately, the recipients of the external benefits--the
public good component of educational output--have no incentive to reveal their true marginal evaluations, so neither market nor nonmarket means can be relied upon to establish the Pareto optimal level of financing for the student's education.

Final comments on education

Two additional points need to be raised regarding the economic theory of education. First, attempts to "internalize" the external benefits of education by increasing the size of school districts will not lead to efficiency in the provision of educational benefits. The external benefits of education are external to the family, and as Davis has commented, "...we cannot increase the size of the family until it is large enough to 'capture' all the benefits of education" (16, p. 19). A final important point is that this analysis nowhere suggests that educational services should be collectively organized and supplied. Although collective action may be desirable to help overcome the free-rider problem in the financing of education, whether or not educational services are provided collectively or by private firms is a matter of relative efficiencies.

Summary

The merit good concept provides a valuable theoretical framework for analyzing a wide range of real world phenomena. For example, viewing education as a merit good provides in-
sights into questions concerning both the demand and supply of educational services. Because education and other merit goods are characterized by jointness, they should be viewed as a form of public goods, not as a type of externality. As public goods, neither market nor nonmarket means can be relied upon to produce Pareto optimality in the provision of merit goods.
CHAPTER VI. SUMMARY

The equilibrium conditions for a system of competitive markets will correspond to the requirements for Pareto optimality only if all prices equal marginal social benefits and marginal costs equal marginal social costs. This analysis has been concerned with the causes of divergencies between private and social net benefits.

Two sources of inefficiency in a system of perfectly competitive markets have been distinguished: externalities and public goods. Externalities are defined as cases of joint supply where all the products are private goods, but where at least one of the products is characterized by infeasibility of exclusion. Public goods are characterized by jointness, where jointness is defined as that property of a good which allows its consumption by one individual not to preclude the possibility of its consumption by others at the same time. Externalities are a private good phenomenon and do not involve jointness, and so the jointness characteristic provides the basis for distinguishing between externalities and public goods as sources of "inefficiency."

Externalities

Externalities are created when goods with nonzero shadow values do not receive their correct price because of the infeasibility of excluding those who would consume the good
without paying. The existence of externalities causes the inefficient use not only of the good characterized by infeasibility of exclusion, but of other factors used in conjunction with that good plus the factors employed in producing the good. This inefficiency is caused by a failure of institutional arrangements, i.e., by a lack of effective enforcement of property rights. The point must be emphasized that the failure is not due to the existence of jointness.

Solutions

In concept, two approaches exist for dealing with externalities. First, externalities obviously would be eliminated by improved modes of enforcement and/or accounting. That is, technological advances or improved institutional arrangements would remove the source of the problem. A second conceptual possibility for eliminating the inefficiencies associated with externalities is through rearrangements of ownership. Specifically, externalities can be internalized by combining the producing and consuming units into a single decision-making unit.

Public Goods

The basis of market failure in the case of public goods is fundamentally different than in the case of externalities. Failure to achieve Pareto optimality in the provision of public goods is owing to consumers' lack of incentive to re-
veal their true preferences for goods characterized by jointness. This lack of incentive stems from a recognition that the possibility exists of consuming units of a public good provided (and consumed) by others. In situations involving small numbers of consumers of public goods the tendency exists for individuals to behave strategically in an attempt to secure differentially favorable benefits. Each consumer seeks to modify the behavior of others in the group in a way which will maximize his own utility. An acknowledged gaming situation exists. In large numbers situations, on the other hand, the tendency for strategic behavior does not exist; rather, individuals adjust their behavior to the behavior of the "rest of the group" taken as a unit, without the anticipation that the group's behavior may change. The individual consumer assumes that the total quantity of public goods supplied will not vary significantly whether or not he contributes to the cost of provision. Thus, he has a strong incentive not to contribute, i.e., to become a free-rider. Clearly, therefore, voluntary behavior generally will not produce Pareto optimality in the provision of public goods.

**Solutions**

Many public goods are provided collectively rather than through voluntary actions. Voting, however, does not guarantee Pareto optimality in the provision of public goods. Unanimity is the only voting rule that is not subject to
the problems of cyclical majorities, and in large groups the unanimous approval of any proposal for cost sharing in the provision of a public good is highly unlikely. It must be concluded, therefore, that neither market nor nonmarket means generally can be relied upon to achieve Pareto optimality in the provision of public goods. This holds not only for "conventional" public goods, but also for merit goods, which are defined as cases in which a public good is supplied jointly along with one or more private goods.

Externalities and public goods present quite different allocative problems, and these problems do not necessarily call for the same "solutions." Whereas inefficiencies associated with externalities can be eliminated through "internalization," the same is not true in the case of public goods. In light of these fundamental differences, care should be taken to distinguish between the two problems. Unfortunately, terms such as "market failure," "social cost," and "externality," as they are usually employed, do not provide a basis for such a distinction.

Allocative Implications

Of the two causes of divergencies between private and social net benefits that have been discussed, viz., externalities and public goods, the most serious allocative problems would seem to be associated with the existence of public
goods. This is based on two observations: (1) cases involving jointness are abundant in the real world whereas externalities probably are not, and (2) the attainment of Pareto optimality in the provision of public goods is virtually impossible, whereas rearrangements of ownership can eliminate the inefficiencies associated with externalities.

If public goods are commonplace in the real world, this leads to a rather uncomfortable situation. Since no one has yet discovered an algorithm for the attainment of Pareto optimality in the provision of public goods, nihilism about much of economics seems to be implied.

In an attempt to answer this rather serious indictment, it is tempting to appeal to the theory of second best. The suggestion might be made that because many divergencies from pure competition exist in the real world, failure to satisfy the conditions for Pareto optimality in the provision of public goods actually may be desirable. Even the attainment of a second best optimum, however, would seem to require that individuals reveal their true marginal evaluations. That is, the introduction of nonrevealed preferences adds a dimension of indeterminacy that would appear to prevent the attainment, in general, either of a Pareto optimum or a second best optimum. The effect of nonrevealed preferences on the theory of second best has received little attention, but is of sufficient importance to warrant further examina-
tion; in fact, much additional research is needed on the whole question of efficiency in the provision of public goods. Until new approaches to this problem are developed, economists may have to take consolation from the fact that most democratic governments show a high degree of stability, which might be viewed as an indication that the provision of most public goods is not grossly inefficient.
LITERATURE CITED


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