I. Introduction to Public Goods Problems

A. Most of economics is concerned with pure private goods, goods that are consumed one person at a time, like a pie.

a. One may be able to share such goods, but in doing so, each person's piece of pie shrinks.

b. For pure private goods, the more people that share the good, smaller each person's piece.

c. For equal shares, the pieces fall in proportion to the number of persons sharing. ($Qi = Q^T/N$, where Qi is an individual's share and Q^T is the amount to be divided among N persons.) .

B. However, some goods can be shared without proportionately reducing the shares of others.

a. For example, a few people can listen to a lecture or concert or TV show without affecting each other's ability to listen to the same lecture, concert or TV show.

b. As the number of persons enjoying such goods or services increases, the quality of the listening experience may diminish, but often do so at different rates. Many more people can listen to a rock concert in an ampitheater than can listen to music in a living room without getting in each other's way.

c. Goods thus vary in their shareability.

d. There is a spectrum of shareability among different goods.

e. Pure private goods are the least shareable and pure public goods are the most shareable of the good types.

C. Goods may also differ in the extent to which they one may be excluded form using a good, which is partly a technological feature of goods and partly a legal distinction.

a. For example, gravity is perfectly shareable but not technologically excludable.

b. On the other hand, fire protection is not particularly shareable and is technologically excludable (only some houses may be served), but legally is shared by all, because of the obligations imposed on fire departments.

c. Many public economics courses stress the non-excludability of many public goods. I do not, because most of the problems associated with public goods emerge from their shareability rather than excludability.[1]

D. The problems associated with public goods resemble those associated with positive externalities. When a persons provides a pure public good everyone benefits from it (or potentially could).

a. If the individual providers to not take account of the spillover benefits generated, they will **under provide** the good or service, which is to say that the amount provided will be smaller than the amount that maximizes social net benefits.

b. In extreme cases, rather than too little of a pure public good being provided, **none may be provided**.

c. In such cases, citizens may ask governments to provide the missing services.

d. The existence of public goods problems may cause voters to demand that particular public services be provided or particular activities be regulated or taxes.

e. As in the case of "ordinary" externality problems, the failure of markets to provide "optimal" quantities of a pure public good is sometimes referred to as a market failure.

II. Pure Public Goods

A. DEF: A **pure public good** is a good that is perfectly shareable.

- A pure public good can be simultaneously consumed by "as many people as want" simultaneously, without diminishing anyone's net benefits.

---

[1] The optimal planting of a vegitable garden from which one can not exclude one's neighbors or pests, will also be smaller than optimal, but not because gardens are public goods.

- Examples include gravity, national defense, the air (breathing outside), and environmental quality.
-

i. DEF A **pure private good** is a good that cannot be shared without proportionately reducing everyone's consumption of the good.
   - Essentially, a pure private good can only be consumed by just one person at a time.
   - Examples include a jelly bean, a pair of shoes, a shirt, a hat, or a nap.
   - (**Most micro-economic analyses and models assume that all the goods and services being analyzed are pure private goods**.)

ii. In between pure private and pure public goods are other goods, most of which can be considered "club goods," goods which are somewhat shareable, but not completely so.

iii. DEF A **club good** is a good that is shareable within limits. A club good can be shared by several people, but the "quality" of the consumption experience falls with the number of people sharing the good, although less than proportionately.
   - Club goods are "congestible."
   - Examples include this lecture, the highways, swimming pools, parking lots, parks, etc.
   - Congestibility implies that there is an ideal number of people who can share a good or service, which is greater than one but less than everyone.

B. Together the existence of pure public, club, and pure private goods implies the existence of **a spectrum of types of goods** that vary according to their "shareability."

   - The more shareable the good is, the closer to the pure public good end of the distribution it is. (See your class notes.)
   - (As an exercise, draw a "spectrum of good types" and provide examples of goods along the spectrum. We'll also do this in class..)
   -

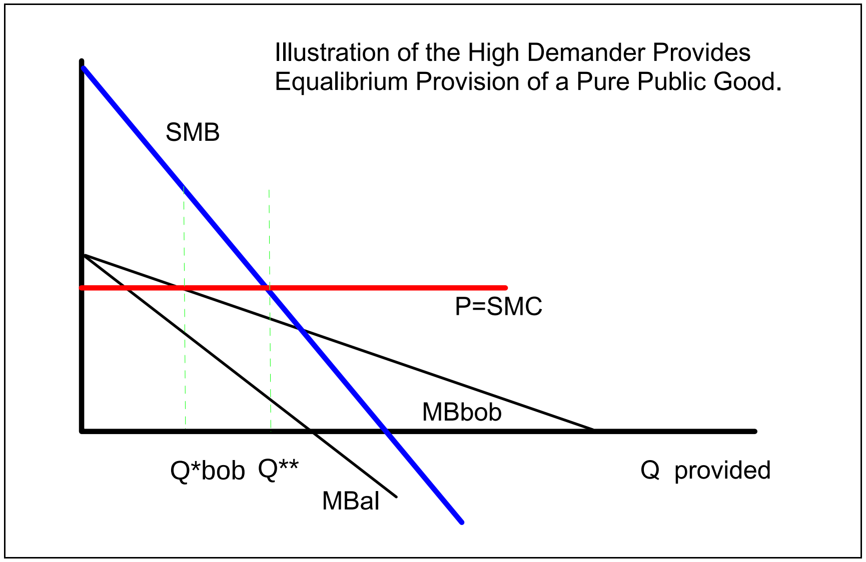
C. Because pure public goods are shareable and are "goods," **the private provision of pure public goods tends to generate positive externalities**.

   - The private production of pure public goods tend to generate **spillover benefits** for those sharing in the services or goods.
   - As a consequence, **pure public goods tend to be under-provided** in the absence of some kind of collective action (as with a club or governmental action).
   - [Note that excluding persons from potentially shareable benefits also causes social net benefits to be lower than they could be. Draw and explain why.]

III. The High-Demander Provides Equilibrium

A. To illustrate the nature of a public goods problem, suppose that there is a two person community with Bob richer than Al or more intensely interested in the public good than Al.

B. Suppose there is a market price for the service and each persons is free to purchase as much as he or she wants. This choice setting is modeled in the following diagram.



i. Our rational choice model implies that only Bob will purchase the service. He will purchase the quantity where his marginal benefits equals his marginal cost, which is labeled Q*bob.

ii. Given that quantity, Al will purchase none of the service, because her marginal benefits are below her marginal costs at that service level.
   - She can free ride on Al's provision, getting significant benefits without any personal costs.

iii. Note that this is not an optimal result under the social net benefit maximizing norm.

iv. If we add the two marginal benefit curves to generate a social marginal benefit curve, we can find the social net benefit maximizing service level, which is labeled Q** in the diagram.

v. The public service is under provided in equilibrium Q*bob < Q**.

vi. (For example if the public good is shoveling snow off sidewalks, the path shoveled may be narrower than that which would maximize social net benefits.)

C. Note that if the price were a bit higher, it is possible that the result would be no provision rather than some positive amount provided by the high demander (Bob).

IV. A Game Theoretic Model of Free Riding

A. The problem of under providing public goods is sometimes called the **"free rider problem"** and can be illustrated using diagrams like that or using a game matrix as developed below.

B. **The free rider problem as a game.**

i. Assume that there are two people each of which can contribute to producing a public good or free ride.

ii. Assume further that the good is "freely available" if the other person pays for it, or if both share the cost of providing it, and that the public good is produces benefits for both persons that are greater than its total cost.
   - The use of a two person game simplifies the analysis.
   - The game can be easily generalized to N persons, if we assume that each person's benefits are greater than 1/Nth of the cost of providing the good, but less than the total cost of the good.

iii. In the two person case, the net benefits associated with various combinations of "provide" and "free ride" can be represented with a "2x2 game matrix."

iv. The matrix characterizes each person's "payoffs" (net benefits) for the four possible combinations of free riding and contributing to the public good.

The Free Rider Problem

Contributions to Providing a Pure Public Good

	Bob: Contributes	Bob: Free Rides
Al: Contributes	A, B 3, 3	A, B 1, 4
Al: Free Rides	4, 1	2, 2

(Payoffs are utility levels or net benefits for Al (A) and Bob (B). Only "rank order" is important. (why?))

a. The payoffs of this public goods game resemble those of the classic "prisoner's dilemma" game (aka, PD game).

b. If each person independently chooses his benefit maximizing strategy, each will choose to free ride.
- If Bob contributes, Al gets 3 if he/she also contributes, but gets 4 if he/she free rides.
- If Bob free rides, Al gets 1 if he/she contributes, but gets 2 he/she free rides.

c. Thus, **regardless of what Bob does, Al is best off when he/she free rides**
- The same logic applies to Bob's choice of strategy.

d. The payoffs imply that Al's and Bob have a **dominant strategy**, a single strategy that generates the best outcome given any choice by the other person(s) in the game.
- DEF: strategy X is a dominant strategy for player i, if and only if it generates the highest payoff for i, regardless of what the other players in the game or contest choose to do.

e. The dominant strategy for each is to free ride.
- Thus in this simple 2x2 game, **each person will tend to free ride** if their strategy choices are made independently of one another.

- Essentially the same logic applies to public goods settings in which there are many persons who must contribute in order to produce the service.

v. The predicted result in such "all or nothing" cases is that all persons in the game free ride.

vi. Nonetheless, Both Bob and Al are better off if the public good is produced (3>2) and 4>1.
- Yet each prefers that the other person provide it (4>3).

C. Free riding is the Nash Equilibrium this public goods game.

DEF: a strategy combination is a **Nash equilibrium**, if no player in the game can alter his or her strategy and achieve a higher payoff.

a. Note that neither person acting alone in the above can make him or herself better off by switching from free riding to contributing, given what the other person is doing!

b. This is true in spite of the fact that there is a Pareto superior move that is possible.

DEF: A **Pareto Superior** move makes at least one person better off without making any other worse off.
- **Note that each person would be better off if the public good is produced.**
- **There is a Pareto Superior move from the lower right-hand cell to the upper left-hand cell (3>2)**.

D. The Nash equilibrium is a consequence of individual rational choice.

i. However in this case, unlike that in normal markets for private goods without externalities, those choices do not produce the social net benefit maximizing outcome.

ii. Privately optimal behavior in this setting, leads to an outcome that is agreed by each to be worse than the case in which they both contribute to providing the public good.

iii. DEF: Outcome A is **Pareto efficient** (or Pareto Optimal), if an only if, there are no feasible Pareto Superior moves from A.

iv. The free rider equilibrium is not Pareto optimal, because there is a Pareto superior move.

E. We now analyze both private and public solutions to public goods / free rider problems.

V. Private Solutions to Public Goods Problems

A. Do nothing.

i. In some cases, the existence of a public good may be compatible with Pareto efficiency or maximizing the net advantage from the activities in question.

ii. That is to say, there may not be a "Pareto relevant" externality at the margin even ignoring transactions costs.

iii. In other cases, nothing may be done, because transactions costs are too great. In such cases, it may cost more to solve the problem than is gained in social net benefits.

B. Formation of Public Service Clubs

i. In some cases, the problem of financing a public good can be solved through voluntary participation in clubs of various kinds.

ii. Club members pay dues, and the dues are used to finance club services that are available for all club members.

iii. The services provided are often local public goods (swimming pools, soccer fields, etc.) and often are excludable. (Otherwise people might free ride rather than join the club and pay their dues).

C. In some cases, a local government can be thought of as a club formed by a group to solve public goods (or externality problems).

a. Such "governing clubs" may be given the power of taxation to solve the free rider problem associated with voluntary financing the service.

b. In such cases. a government can be thought of as a special kind of club--a voluntary association--with the power to tax.

c. This tends to be more true of local governments than national governments, insofar as membership (residence) in a local government's jurisdiction tend to be voluntary.

- (One could easily live in another nearby town.)
- This is less true with respect to national jurisdictions.

VI. The Ideal Governmental Provision of a Pure Public Good

A. In some cases, it will be easier for a group to take over production of a public good rather than to provide the proper Pigovian subsidies to encourage Pareto efficient private production.

B. In 1954, Paul Samuelson wrote a very influential short paper in which he characterized the ideal tax and production solution to a pure public goods problem.

- His solution requires Q** to be produced, as in our diagrams above.
- It also characterizes properties that Pareto efficient tax systems for financing pure public goods.

C. Samuelson's solution requires:

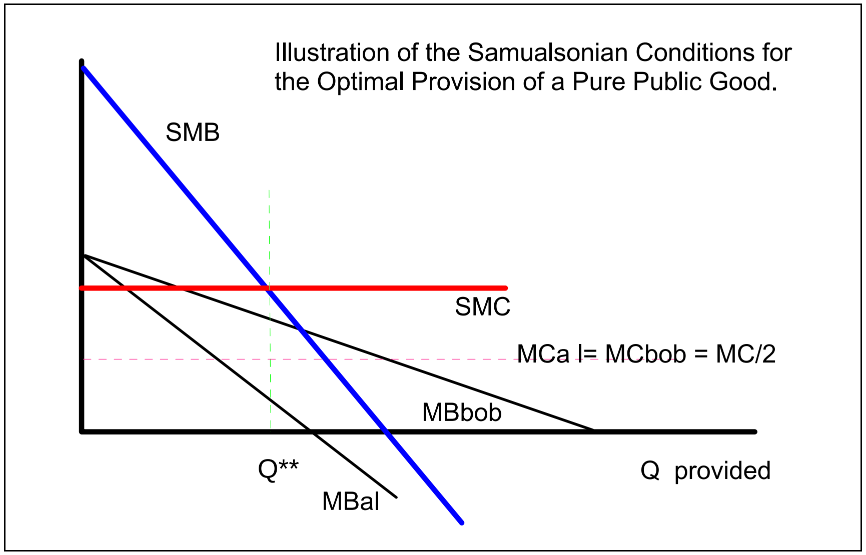
i. Taxes that do not impose a deadweight loss. (Broad-based or lump sum taxes)

ii. Taxes that generate just sufficient revenue to cover the cost of the public services.

iii. Taxes for which the sum of the marginal costs imposed on users of the public good equals the marginal cost of producing the public good.

iv. (These conditions, optimal production of government services financed by an efficient tax system just sufficient to cover the costs of the services, are sometimes called the **Samuelsonian conditions for the optimal provision of a pure public good**.)

v. (The figure below illustrates one of many possible Samuelsonian solutions. A solution in which costs are equally shared, as in many private clubs.)



D. There are several important features of Samuelsonian solutions to public goods problems.

i. First, it is an attempt to take account of both sides of the fiscal equation: both expenditures and taxes are simultaneously optimized.

ii. Second, it shows that even when people disagree, there is a Pareto efficient outcome--which in our diagrams is often unique.

iii. Third, it shows that there are a lot of Pareto Efficient methods of financing a pure public good--once Q** is determined, more or less any division of the cost of Q** units will be Pareto efficient.

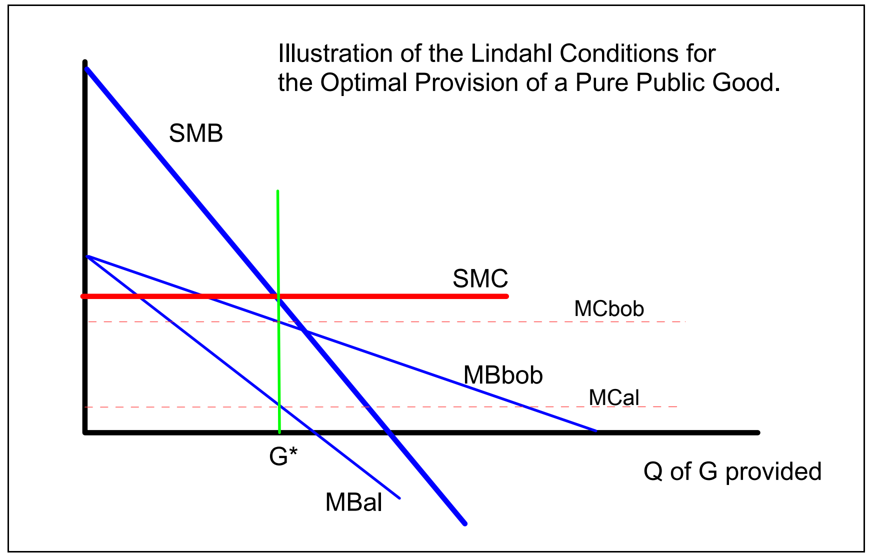
iv. (However, not every shift from a free rider solution to a Samuelsonian solution will be a Pareto superior move. Explain why.)

E. One problems with most "Samuelsonian Solutions" to public good problems, is that the individual tax payers are often "unhappy" with the amount of the public service provided, given their tax cost.

F. A special case of the Samuelsonian Solution that avoids this problem is the **Lindahl tax system**.

- (Erik Lindahl, a Swedish economist, figured out his solution decades before Paul Samuelson figured out his more general solution.)

G. To the Samuelsonian conditions, **Lindahl** argues that *taxes should equate marginal benefits and marginal costs for individuals at the optimal output* of government services.



i. Lindahl is important because is shows that even in cases in which people disagree about the value of a public service, there are tax systems that can increase consensus.

a. Indeed in the Lindahl case, it is possible to produce a tax system under which there is unanimous agreement about the ideal service level (given the tax shares).

ii. Lindahl taxes are also of interest, because it turns out that every shift from a "pure" free rider outcome, an outcome in which Q'=0, to a Lindahl solution will be a Pareto superior move.

a. Everyone will be made better off (consumer increases from 0 to Q** when it is paid for with Lindahl taxes.

b. (As and exercise, illustrate why this is true.)

iii. It bears noting, however, that shifts from a "high demander supplies" equilibria with significant services under private supply to a Lindahl solution will not necessarily be a Pareto superior move.

a. (Explain why a high demander outcome might be preferred by a free rider to a Lindahl tax solution.)

b. Although it is always possible to devise a Lindahl tax scheme that will generate a Pareto Superior move.)

H. **Lindahl taxes** are considered to be an idealized form of **benefit taxes**.

a. In this case, everyone in the society of interest is completely satisfied with the level of public goods provided.

b. This makes the Lindahl tax system a very important special case of the Samuelson solution.

c. In the usual Samuelsonian case, it is possible that essentially all people will be quite dissatisfied with the services levels provided by government! Those whose marginal tax cost are below their marginal benefits from the service will demand more, whereas those whose marginal tax cost is above their marginal benefits will want less!)

VII. Appendix on Pareto Superior Moves and Pareto Efficiency

A. DEF: Outcome A is **Pareto superior** to Outcome B, if and only if at least one person is better off at A than at B and no one is worse at B than at A.

B. DEF: Outcome A is **Pareto efficient** (or Pareto Optimal), if an only if, there are no feasible Pareto Superior moves from A.

i. Outcomes that maximize social net benefits are normally Pareto efficient.

ii. However, outcomes that do not maximize social net benefits may also be Pareto efficient.

- (Such cases often occur in game matrices, although not market-based diagrams. Coasian bargains are both Pareto efficient and maximize social net benefits.)

C. Consider the Diagram below and explain why:

i. Z is Pareto superior to X

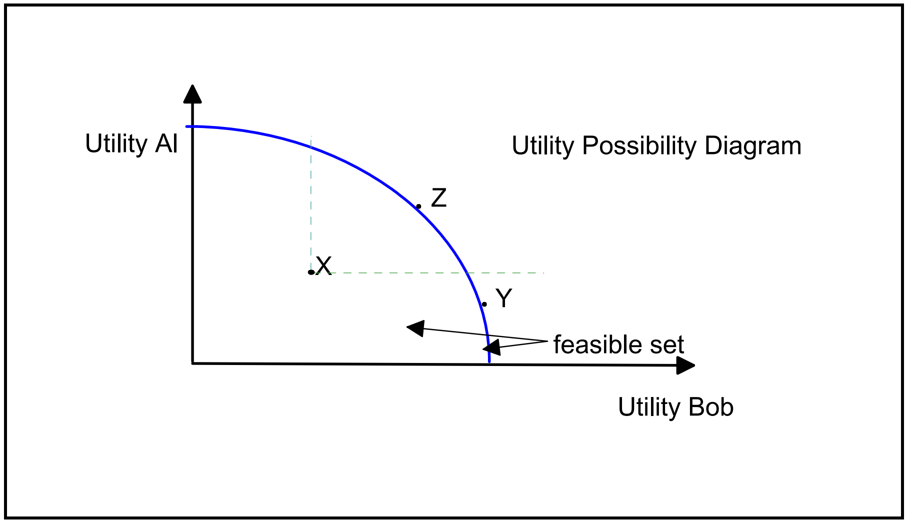
ii. Z and Y are Pareto Efficient

iii. Y is not Pareto superior to X

iv. The outer edge of the feasibility set, is often called the “Pareto frontier” because it includes all the Pareto optimal points. (Explain why this is often true. Draw an exception to this rule.)

v. Shade in all the possibilities that are Pareto superior to X.

vi. Explain the implicit economic assumptions behind the “utility possibility set.”


Utility Al
Utility Possibility Diagram
Z
X
Y
feasible set
Utility Bob