I. Market Failure and the Demand for Government Services

A. The theory of public finance often begins with an analysis of taxation.

i. This approach is useful if the government is considered to be a revenue maximizing leviathan and also for some pedagogic reasons (the tools are simpler).

ii. Tax theory, however, is a less useful if the government is considered to be a more or less representative one, because in that case **the demand for services comes before** the demand for revenues.

B. Economics provides a variety of explanations for the demand for government services.

i. The demand for government services in many cases can be represented in much the same way as the demand for other public services--that is consumer-taxpayers demand them because they increase personal utility.

ii. In such cases, however, the question arises as to why the service is produced by government rather than ordinary market enterprises.

If consumers have choices among alternative producers of a service they will normally choose to purchase from the organization offering the lowest prices?

Are there cases in which a government is likely to be the least cost provider of a service?

iii. It turns out that there are several cases in which the government may be the least cost provider of a services.

For example, it may use tax revenues to subsidize the production of a service in a manner that reduces its price to a level below that which firms could provide the services.

However, if the tax paid for a subsidy is included in the price, this possibility is less likely--at least as far as the **average** tax payer is concerned.

iv. The most plausible case in which a government will be the least cost provider of a service is if when desired services are not efficiently provided by firms that operate in normal market conditions.

Common examples include pure public goods and other services which are produced under fairly extreme economies of scale.

If the former case, a service will be under provided, and in the latter natural monopolies tend to emerge that may charge more for the service than a representative government will.

In such cases, there is often said to be a **market failure**.

This might be said, for example, of national defense, law enforcement, highways, fire protection, water sanitation, and standards.

v. In other cases, the government will not directly provide the service but may regulate production in some way, and change incentives through fines, taxes, or subsidies for producing a given service privately.

A service may be produced at Pareto inefficient levels because of externalities associated with production or consumption of it.

In some cases, "externality problems" are the result of the technology of production and in others a consequence of the "property rights" under which a service is produced.

vi. Normative and positive theories of redistribution and social insurance provides other rationale for the demand for government, but we will postpone consideration of those sources of the demand for government services until later in the semester.

C. The economics of "market failure," thus, can be used to provide an efficiency rationale for taxpayer demand for government services.

i. This rationale can be regarded as normative--as utilitarian--in the way that it is used to justify government provision of services or targeted taxation.

ii. However, it can also be regarded as contractarian in the positive sense that if "everyone" believes that service A should be provided by the government, then it will be.

- Government solutions to "market failures" provides the core economic explanation for "productive states."
- They are also important rationales for government action in normative contractarian theories of the state.

iii. Alternatively, one may want to model government decisionmaking more closely, as in Public Choice or Political Economy in order to determine how individual "demands" for service affect the policies that actually determin them.

- We will explore these more institutional and political approaches to the supply of government services next week.
- These models imply that government policies do not always solve (or address) market failures.
- Indeed, they also allow the possibility of government failures--policy areas in which less the best policy choices are made and also cases in which no policies would have been better than the interventions undertaken.
- (As in theories of market failure, theories of government failure require a normative theory to draw such conclusions.)

iv. For the most part, we will use **utilitarian** (social net-benefit maximizing) normative theory today both as a source of **normative** "efficiency" claims and also as part of a **contractarian rational for voluntary collective action** concerning the problems identified.

II. Pure Public Goods as a Source of Market Failures

A. Some useful definitions:

i. **DEF**: A **pure public good** is a good that is perfectly sharable. A pure public good can be simultaneously consumed by "as many people as want" simultaneously. Examples include gravity, national defense, the air (quality), and gravity.

ii. **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 only one person at a time.

Examples include a jelly bean, a pair of shoes, a shirt, a hat, or a nap. (Most economic analysis assumes that goods and services are pure private goods.)

iii. **DEF** A **club good** is a good that is sharable within limits. A club good can be shared by several people, but the "quality" of the consumption falls with the number of people sharing the good, although less than proportionately.

Club goods are "congestable," the benefits that a person recieves from the good falls as the number of users increases.

Examples include this lecture, the highways, swimming pools, parking lots, parks, etc.

iv. Because provision of pure public goods tends to generate positive externalities (see below), pure public goods tend to be under provided in the absence of some kind of collective action (which is not necessarily governmental provision of the service).

B. The problem of under providing public goods is sometimes called the **"free rider problem."**

i. A relatively **extreme form** of the free-rider problem can be illustrated with a 2x2 game matrix.

- Other continuous geometric and mathematical representations are also possible (see below)

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

(Individual payoffs are in (ordinal) utility terms. Note that "rank order" is sufficient to illustrate the essential logic of this social dilemma.

ii. Note that both Bob and Al are better off if the public good is produced (3>2), yet each prefers that the other person provide it (4>3).

- The payoffs to such social settings resemble those of a "prisoner's dilemma" game.

iii. If each person independently chooses his benefit maximizing strategy, each will choose to free ride.

Note that if Bob contributes, Al gets 3 if he/she also contributes, but gets 4 if he/she free rides.

- Note that if Bob free rides, Al gets 1 if he/she contributes, but gets 2 he/she free rides.
- Thus, **regardless of what Bob does, Al is best off if he/she free rides**.

Note that essentially the same logic applies to Bob's choice of strategy.

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

iv. The **Nash equilibrium** of the free-rider game is **mutual free riding**.

- The result is individually rational, **but each person would be better off if the public good is produced. (3>2)**
- 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.
- (3, 3) is Pareto superior to (2, 2).
- (Note that this provides a reason to expect collective action to attempt to solve the problem, and implies that resources might be available to construct institutions that can address it. why?)

C. A similar, but often less severe, free-riding problem can be shown to occur in continuous representations of the production of pure public goods.

i. Suppose that G is a pure public good and X is a pure private good and that Al and Bob have similar utility functions and budget constraints, $U^A = u(G, X^A)$ and $W^A = G + PX^A$

ii. Al's utility maximizing quantity of the pure public good can be found by substituting for XA in her utility function, $X^A = (W^A - G)/P$ and for G with $G = G^A + G^B$

- Recall that if G is a pure public good, each person gain full benefits from the other's purchase of the good.
- Which yields: $U^A = u(G^A + G^B, (W^A - G)/P)$

iii. Differentiating with respect to G yields Al's ideal purchase of G:

- $U^A_G = u_G - u_X/P = 0$ at G^{A*}

Which implies that $G^{A*} = g(G^B, W^A, P)$

(This equation is A's demand for the public good, and also her "best reply function" for the free rider public goods game)

iv. The mathematics for Bob yields a similar result:

$G^{B*} = g(G^A, W^B, P)$

v. At the Nash equilibrium:

$G^{B*} = g(G^{A*}, W^B, P)$

and $G^{B*} = g(G^{A*}, W^B, P)$

vi. The **Pareto efficient level G** can be characterized using a Benthamite social welfare function (and other similar methods).

- $W = U^A + U^B$

Differentiating with respect to G^A and G^B yields the first order conditions that describe the Pareto efficient levels of G^A and G^B

- $W_{GA} = u^A_G - u_X/P + u^B_G$
- $W_{GA} = u^B_G - u_X/P + u^A_G$

Note that **these two first order conditions describe functions that are "outside" of Al and Bob's best reply functions**, because they each require the external benefits of the other person to be taken account of.

- [Draw the figure that illustrates this conclusion.]
- Thus, the Nash equilibrium of this continuous version of the free rider game is Pareto sub optimal.
- Too little of the public good is purchased by each.
- However, some of the public good does get privately produced!

D. There are a variety of solutions to public goods problem, including explicit coordination among those free riding, the formation of "public goods" clubs, private contracts (agreements) to contribute to produce the public good, and government action.

- In small number cases like that of the 2x2, the persons affected may form a small club and perhaps hire a manager to solve the problem.
- In large number settings it will of ten be cheaper to use the government that to form a new club for this purpose.

III. Pareto Optimal Provision of Pure Public Goods

A. Within democracies, many government services can be understood as attempts to solve various free rider problems.

i. 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 sufficient production.

ii. This may be done privately through clubs, or publicly through governments of one kind or another.

iii. In such ideal cases, **government can be thought of as a special kind of club with the power to tax**.

- (Such clubs are good examples of what would be justified under contractarian theories of the state.)

B. Samuelson in a classic 1954 paper on the optimal (utilitarian) supply and financing of a pure public good characterizes the ideal way to finance the "collective" production of such public goods.

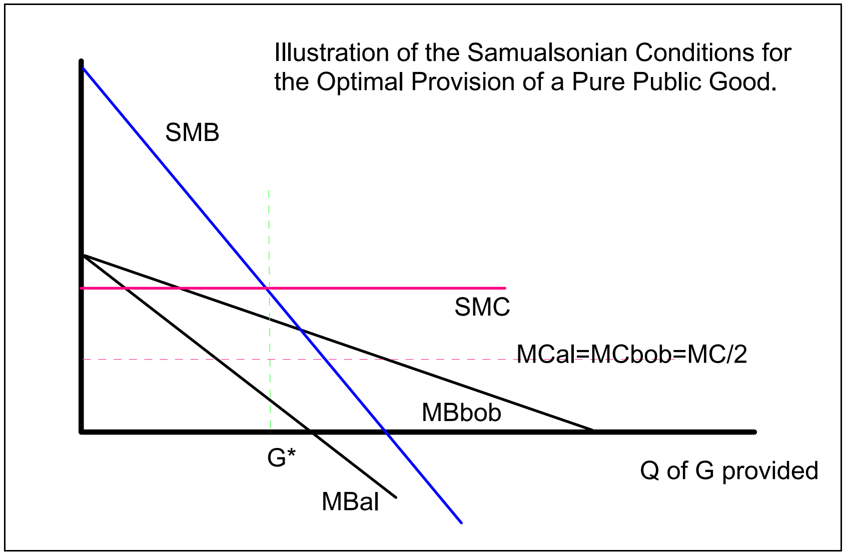
i. Ideally, the government would provide services at the Pareto optimal level, or, equivalently, at the level that maximizes social net benefits.

ii. The ideal taxes do not impose a deadweight loss. (Broad-based or lump sum taxes)

iii. They should raise just sufficient revenue to cover the cost of the public services.

iv. The sum of the marginal costs imposed on users of the public good should equal the marginal cost of producing them.

v. (These four conditions, optimal production of government services financed by an efficient tax system are sometimes called the **Samuelsonian conditions for the optimal provision of a pure public good**.)



C. The essential mathematics of the Samuelsonian characterization of the Pareto optimal collective provision of a pure public good.

i. First we need some private choice notation: Let G be the level of a pure public good, let Xi be the level of a pure private good received by individual *i*, let Ui = u(G, Xi) be the utility of individual *i* associated with a particular combination of the public good and private good received by *i*

ii. Second, we need some macro-choice notation. Let W be a social welfare function and let T(G,X) = 0 be the technological frontier of combinations of the public good and private goods, with X = ΣXi.. Suppose there are N persons in the society of interest.

iii. The problem of maximizing social welfare can be written as a Lagrangian:

- max $\mathcal{L} = W(U_1, U_2, U_3 \ldots U_N) - \lambda\, (T(G,X))$

iv. Differentiating the Lagrangian with respect to G, $X_1, X_2, X_3 \ldots X_N$, and λ yields the first order condition for the social welfare maximizing level of G and for the distribution of private goods--which we will ignore for the purposes of this derivation.

- $\Sigma W_{Ui} Ui_G = \lambda T_G$
- $W_{Ui} Ui_X = \lambda T_X$ for all i = 1 ... N (This represents N equations)
- $T(G,X) = 0$

v. After obtaining the Lagrangians first order conditions, the next step is to manipulate the first order conditions into a form that is both economically interesting and useful. Samuelson uses a rather clever series of steps to do so.

First, divide the first and second condition to eliminate the lamda.

- $[\Sigma W_{Ui} Ui_G]/ W_{Uj} Uj_X = T_G / T_X$
- (I have used the jth of the foc's for the private good to avoid confusion with "i" the counter for the summation in the numerator)

Since the denominator does not change with "i" it can be brought inside the brackets--because it is essentially a constant as far as this fraction is concerned.

- $[\Sigma W_{Ui} Ui_G / W_{Uj} Uj_X] = T_G / T_X$
- Now note that the foc's for the private goods imply that $W_{Ui} Ui_X = W_{Uj} Uj_X$
- This condition holds for all "i" and "j" (for every person's private good).

This equivalence means that you can rewrite the equation under part b as:

- $[\Sigma W_{Ui} Ui_G / W_{Ui}Ui_X] = T_G / T_X$
- by substituting the various "i-terms" for the "j" term that we started with.
- This allows us to simplify a bit:
- $\Sigma [Ui_G / Ui_X] = T_G / T_X$

The ideal level of a pure public good will set the **sum of the marginal rates of substitution between the private and public good equal to the technological rate of transformation** between them.

- (In the diagram above, this condition is represented by setting the sum of the marginal evaluation curves equal to the marginal cost of the pure public good.)
- Note that **the optimal provision of a pure public good is completely independent of the social welfare function** used.

D. There are a variety of practical problems with this characterization of the Pareto optimal provision of a pure public good, but the political one is of particular interest for the purposes of this course.

- ♦ Most Pareto efficient provisions of a public good make individual tax payers "unhappy" with the amount of the public service provided, given their tax costs.

E. There is, however, a special case of the Samuelsonian Solution that avoids this problem, namely the **Lindahl tax** system.

- (Lindahl, a Swedish economist and student of Wicksell, surprisingly figured out this solution decades before Samuelson figured out how to characterize the Pareto efficient level of a pure public good..)

F. Lindahl adds another condition to the three Samuelsonian conditions for Pareto efficient provision of a pure public good.

- **Lindahl** suggests that the *taxes used to finance public services should* ***equate marginal benefits and marginal costs for individuals at the desired output*** **of government services**.
- Lindahl taxes are, thus, said to be idealized **benefit taxes**.

i. They can also be applied to finance the Pareto efficient level of a pure public service, G*, characterized by Samuelson..

ii. **Under Lindahl taxation, everyone in the society of interest is prefers the Pareto optimal level of public goods to all others**.

- [See the in-class lecture notes for an illustration of Lindahl taxation.]

Note that under a perfect benefit tax of this sort, each person "demands" the same output of the pure public good, namely G**.

This contrasts with the less restricted Samuelsonian case, in which persons are very likely to disagree about the best service level to provide!

- (Consider for example the special case in which the cost of the service is shared equally among three persons with different marginal benefit curves.)
- 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!

Lindahl taxes would induce unanimous agreement about the level of a pure public good to be provided, and so suggest that collective action to solve public goods problems in this way may well be undertaken.

- [This would, of course, require providing institutions that assure that taxes are paid. Free riding on contributions to the public good remain rational even under Lindahl taxes.]

IV. A Digression on Lindahl Taxation if residents have similar Cobb-Douglas utility functions.

A. There is **an interesting special case of Lindahl taxation** that arises when all persons on the polity have identical tastes that can be represented with a Cobb-Douglas utility function, but they have different wealth endowments.

i. Let G be the pure public good and C be private consumption and assume that "t" is the price of the pure public good and "P" is the price of the pure private good.

ii. In this case, "Mr/Ms i" maximizes $U_i = C_i^a G^{1-a}$ subject to $W_i = tG + PC_i$

B. Mr/Ms i's demand for the government services given this tax-price system for financing the public service can be derived by (i) forming a Lagrangian (which works well for C-D functions), (ii) differentiating with respect to C_i, G, and λ, and (iii) doing some clever algebra.

i. $\mathcal{L} = C_i^a G^{1-a} + \lambda (W_i - tG - PC_i)$

ii. Differentiating with respect to C_i, G, and λ, setting the results equal to zero, and some simple algebra yields:

$(1-a)C_i^a G^{-a} = \lambda t$

$aC_i^{a-1} G^{1-a} = \lambda P$

$W_i = tG - PC_i$

iii. Some more "easy" algebra on these three first order conditions allows Mr/Ms i's demand for G to be characterized.

Dividing "a" by "b" yields: $[(1-a)/a]\,[C^*/G^*] = t/P$

Solving for C_i^* yields: $C_i^* = G^* (t/P)\,[a/(1-a)]$

Substituting for C in the budget constraint: $W = tG^* - PC_i^*$ yields
$W_i = tG^* - P\,G^* (t/P)\,[a/(1-a)]$

Simplifyng and solving for G_i^* yields $G_i^* = (1-a)W_i/t$

- As normally the case with C-D utility functions, each person spends a **particular fraction of their wealth** on the goods of interest, here (1-a), and the amount purchased varies with the price, here (t).
- In the special case of interest here, everyone spends the same fraction of their wealth on each type of good.

iv. A Lindahl tax system has the property that it induces each person to demand the same quantity of the public good. (See the diagrams above.)

We can use this property to characterize the Lindahl tax prices for this polity.

Each person pays a different price under a Lindahl system, here t.

Those taxes induce each to purchase the same quantity of goods so for persons "i" and "j," $G_i^* = G_j^*$ at their respective Lindahl taxes.

Assume that G** is the Pareto optimal quantity of the pure public good and that "t" satisfies the Samuelsonian condition and, so, is just sufficient to pay for the pure public good [that is: $\Sigma t_i G^{**} = c(G^{**})$].

- In this case the Lindahl taxes satisfy: $(1-a)W_i/t_i = (1-a)W_j/t_j$
- and $t_i/t_j = W_i/W_j$
- That is to say if "i" has twice as much wealth as "j", i's tax price should be twice as high as j's.

In this special case [identical Cobb-Douglas tastes and $\Sigma t_i G^{**} = c(G^{**})$], a progressive tax that has marginal tax rates equal to relative wealth (or income) is a Lindahl tax system.

C. Of course, preferences differ and are not likely to all take the form of Cobb-Douglas utility functions, and this tax financing scheme might not be sufficient to pay for the pure public service.

i. However, it is interesting to note that Lindahl taxation would require progressive wealth (or income) taxation, **except for** differences in tastes and economies and/or diseconomies of scale in producing government services.

ii. Moreover, it is interesting to note that in "easy circumstances" one does not have to determine each person's unique marginal benefits schedule (or marginal rate of substitution).

- Are there any communities that have progressive real estate taxes, or are they all flat systems? If so, is there more consensus about the level of services in such communities?
- If there is not greater consensus, this would suggest that taste differences were important. People of similar income may have quite different demands for bicycle paths, day care centers, parks etc.. Explain.

V. Externalities and Public Goods: Definitions and Geometry

A. DEF: An **externality** occurs whenever a decision made by an individual or group has effects on others not involved in the decision.

- That is to say, an externality exists whenever some activity imposes spillover costs or benefits on other persons not directly involved in the activity being analyzed.

i. Generally, an activity that imposes *external losses* (costs) on third parties at "the margin" will be carried out at levels greater than that which maximizes the social net advantage from the activity.

- This follows because the people who decide the level of the activity that gets carried out tend to focus only on their own costs and benefits.
- [Note that this is a positive prediction about behavior--that spill over costs and benefits will be ignored by those controlling the activity.

ii. Generally, an activity that imposes *external benefits* on third parties at "the margin" will be carried out at levels below that which maximizes the social net advantage from the activity.

- The production of pure public goods often tend to produce such external benefits. (why?)
- Within environmental economics, polluters ignore spillover costs, while pollution controllers ignore spillover benefits associated with cleaning up.

B. Demonstrating the existence of externality "problems" requires a normative framework and assumptions (positive predictions) about how firms and consumers make decisions when there are spillover costs and/or benefits.

i. The problem from the point of view of welfare economics is not externalities themselves, but rather that **the wrong level (too much or too little) of the externality generating activity gets produced to maximize social net benefits**.

Consider, for example water pollution.

- Water pollution imposes costs on other users of a river or lake, and tends to be over produced. However, the optimal amount of pollution is not generally zero! The "optimal" amount of water pollution sets the marginal cost of cleaning up the pollution equal to the social marginal benefits of engaging in the polluting activity. (See the diagrams below.)

In nearly every case in which an *environmental problem* is claimed to exist--the underlying "economic problem" is an externality problem.

ii. It bears noting that some activities generate external benefits for some people, but external costs for others.

- For example, some people might be allergic to the flowers planted under "b."

C. To find out (geometrically) whether an externality generating activity or output is over or under supplied, we first add the marginal benefit (or marginal cost curves) up to find the social marginal benefit (or cost) of the activity in question.

i. **In effect, an externality generating activity generates benefits or costs for a wide range of people simultaneously.**

ii. **So, the social marginal benefit and marginal cost curves for such activities are "vertical" sums of the relevant individual and firm MB and MC curves**.

iii. The level of the activity that maximizes social net benefits is generally found where the social marginal benefit of the activity equals its social marginal cost curve.

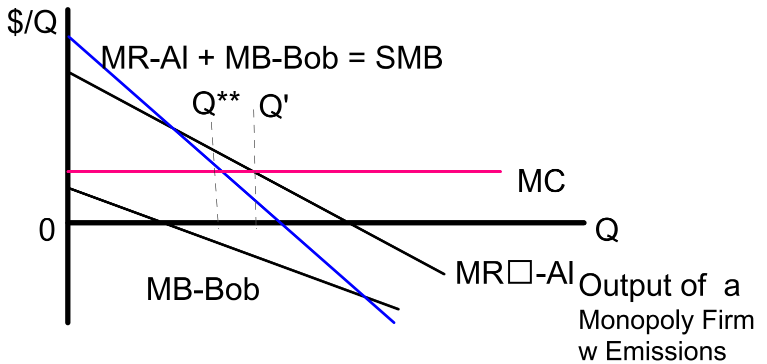
- (Recall that net benefits are "normally" maximized where the relevant MB and MC curves intersect.)

iv. For example, in Figure 1, note that at Al's preferred output level, Q', (the one that maximizes her own net benefits) there are spill over **costs** at the margin. Al's production makes Bob worse off *at the margin*.

Consequently, the activity being analyzed is provided at greater than optimal levels.

Q' is larger than Q**, the quantity where net social benefits are maximized.

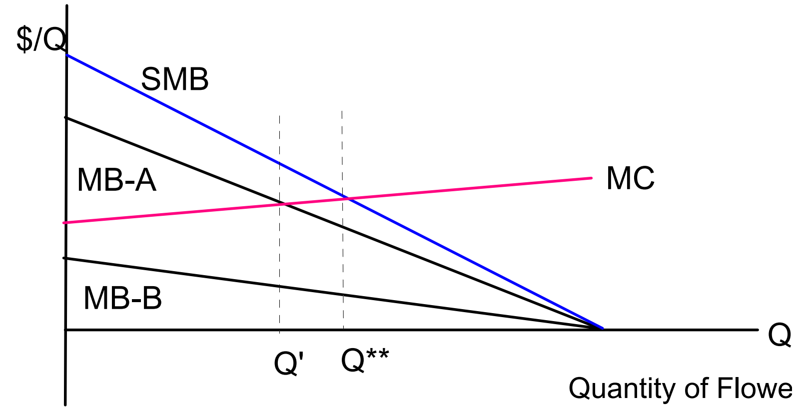
Figure 1: An Excess Supply of a Polluting Activity



v.

D. In Figure 2, an activity with positive externalities (benefits) is depicted.

Figure 2: Under Supply of an Activity Generating Positive



E. Note that the mere existence of an externality does not necessarily imply that there is an externality problem.

i. One may privately reach **the Pareto optimal level of an externality generating activity if there are no external benefits or costs at the margin** (e.g. at Q'), but in other cases some form of collective action will be required to "solve the externality problem."

ii. For example, marginal benefits or marginal costs may be zero at Q'.

iii. [Depict such a case as an exercise.]

F. These special cases imply that the conclusion that external cost producing activities are over provided relative to that which maximize social net benefits, and that external benefit producing activities are under provided relative to that which maximizes social net benefits are simply useful rules of thumb, even if social welfare theory is accepted and the assumed form of behavior takes place.

- With respect to the latter, it bears noting that many **norms** for private conduct in social settings seem to have **evolved to solve** externality and free-riding problems.
- See for example, Axelrod (1981) or Congleton and Vanberg (1992).

- **A good deal of civil, criminal, regulatory, and environmental law appear to be attempts to solve externality problems.**
- (To the extent that these norms and laws work, externality problems will be smaller than predicted by public finance models. Indeed some externality problems can be solved by creating appropriate "property rights.")

VI. Some Basic Mathematics of Externalities in Competitive Markets

A. There are essentially three types of externalities:

Pecuniary externalities: effects of changing relative prices on the value of individual holdings of wealth. (Automobiles impoverished buggy whip manufacturers.)

Technological externalities: effects of one firm's (or consumer's) output decisions on the costs of other firms. (Effluent upstream increase the cost of drinking water down stream.)

Consumption externalities are the most studied. Consumption externalities occur when one person's activity(s) directly affects another person's utility level. Here the effect is directly included in an individual's utility function. (Al enjoys Bob's garden. Jane is made "ill" by Dick's red shirt, or choice of music, etc.)

B. The essential mathematics of externality problems are quite straightforward:

i. Suppose that Al and Bob are neighbors, and that Al likes to barbecue steaks on a grill in his back yard. The resulting smoke affects both Al and Bob, neither of whom care for smoke.

Suppose that Al allocates time between cooking outside and inside, and for purposes of analysis that these are the only two uses of his time. Al's cooking time constraint is T = I + O.

The amount of smoke produced is S = s(O), his output of barbecued food is F=f(O) and of indoor food is G = g(I).

Al's utility function is U=u(F, G, S) with F and G being goods and S a bad.

Bobs decision calculus is not of particular interest so his welfare can be represented as Ub = ub(K,S) where K is some other activity, held constant at this point (alternatively it could have been optimized various smoke levels).

ii. Substituting yields: U = u(f(O), g(T-O),s(O))

Differentiating with respect to O yields: $U_F F_O - U_G G_I + U_S S_O = 0$ at O*

Note that the last two terms represent the marginal cost of outside cooking. The first is AL's marginal benefit from barbecued food.

iii. The Pareto optimal level of barbecuing can be characterized using W = w(U,Ub) where W is a social welfare function, U is Al's utility and Ub is Bob's utility.

Differentiating with respect to O yields

$W_U [U_F F_O - U_G G_I + U_S S_O] + W_{Ub} Ub_S S_O = 0$ at O**

Note that *only in the case where the last term is zero* does Al's private maximizing choice yield a Pareto optimal result.

- (Note that the terms in brackets characterizes Al's choice since these are Al's f. o. c. for his O*.)
- [Explain why we can use an "arbitrary" social welfare function to characterize a Pareto optimal state.]

VII. Private Solutions to Externality Problems:

A. Do nothing

i. In some cases, the existence of an externality or pure 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.

B. Privatization

i. In some cases, the reason for the externality is simply an improper specification of property rights.

ii. For example, commons problems involving non-circulating or readily identifiable resources such as land, can be addressed by granting a person, firm, or club exclusive rights to control the usage of the resource in question.

Privatization may solve such commons problem even if the "user rights" are not tradable, because *owners have no incentive to overuse their own resources.*

(Privatization is not, strictly speaking a private solution because it normally requires government intervention to characterize the rights and to enforce them—although once implemented such "user rights" require no more enforcement than other civil or criminal law.)

C. Coasian Contracts (Private Agreements)

i. In other settings, privatization may not be sufficient by itself to eliminate an externality problem, but it may be possible for the affected parties to contract with one another to solve the problem, given improved property rights.

ii. For example those affected by pollution may pay the polluter not to pollute.

iii. Alternatively, those wishing to engage in a negative externality producing activity (pollution) may pay those who will be affected by that pollution for the privilege.

iv. The Coase theorem (R H Coase 1960) says that if (a) property rights are well defined (or contracts enforced) and (b) transactions costs are negligible, then voluntary exchange can solve essentially all externality problems.

v. Moreover, in its strong form: if (c) there are no significant income (original endowment) effects, then the **final result tends to be the same regardless of the original assignment of property rights**

"a through c" is sometimes called the Coase theorem.

It bears noting that part "c" of the "Coase theorem" **requires the Pareto set to be composed of a single point,** which is often the case in our diagrams, where there is a unique output level that maximizes social net benefits. (Explain why will not be true in more general circumstances.)

vi. An Intuitive Example.

Suppose that a factory, Acme, uses a production process that produces smoke along with its marketable output. The wind mostly comes out of the West so that the smoke fall mostly on homeowners who live East of the factory .

The *weak form* of the Coase theorem (a and b) suggests that voluntary exchange can be used to solve the externality problem. The home owners can band together and pay the firm to reduce its emissions either by reducing output or by using pollution control devices.

Gains to trade exist because at the margin, the firm realizes no profits from the last unit sold, but the home owners association is willing to pay a positive sum to get the firm to produce less.

Notice that very similar gains to trade would exist if the home owners initially had veto power over the firm's output. In this case, the firm would be willing to pay the home owner association for the privilege of producing its output and smoke.

Whenever transactions costs are small, contracts can be developed (trade can take place) that completely solve the externality problem in the sense that after the "Coasian contract" all gains from trade are realized, and net benefits are maximized.

vii. The *strong form of the Coase theorem* holds if transactions costs are low and there are no important income effects that arise from the assignment of control over the resource or activity of interest.

In such cases, Coasian contracts will always reach the same output level, insofar as there is a unique output that maximizes social net benefits--as it often is in our diagrams.

In this case, the **final outcome is the same no matter who controls the resources** after all gains from trade are realized!

(In other words, the gains to trade are exhausted at the same output level regardless of the initial assignment of control (property rights). For this and one other important insight about the nature of firms Ronald Coase won the Nobel Prize in economics.)

viii. The Coasian approach to externalities implies that essentially all externalities are reciprocal in the sense that who "creates" the externality depends on the original assignment of control.

In the case where the home owners association control the resource, their decision imposed large costs on Acme!

And vice versa. If Acme controls the output or activity level, then the home owners are made worse off.

However, the process of exchange always makes both parties better off, given their original circumstances.

The original property rights assignment affects the direction of payments, although not the final output level in a Coasian world.

ix. An Illustration of the geometry of the Coase Theorem

Suppose that the firm, Acme, initially controls the output or emissions. In this case, in the absence of a Coasian Contract, the outcome will be an output that maximizes profits such as Q*.

Note that unrealized gains to trade exist at Q*. The home owners are willing to pay more for reductions in output than the firm earns as profits.

The last unit that the homeowners can afford to compensate the firm for "not to producing" is Q** where the marginal compensation required by the firm (the marginal profit labeled x) equals the willingness of the home owner association to pay for it (the marginal external cost labeled x).

Note that the result is not changed by a reassignment of property rights. Had the homeowner association initially had veto power over the firm's activity, they will set output at 0 in the absence of a Coasian contract. ("0" minimizes cost imposed on them by the firm.)

Clearly, gains to trade also exist in this case. The distance from the MR curve to the firm's MC curve is much larger than the size of the marginal external cost borne by home owners at 0.

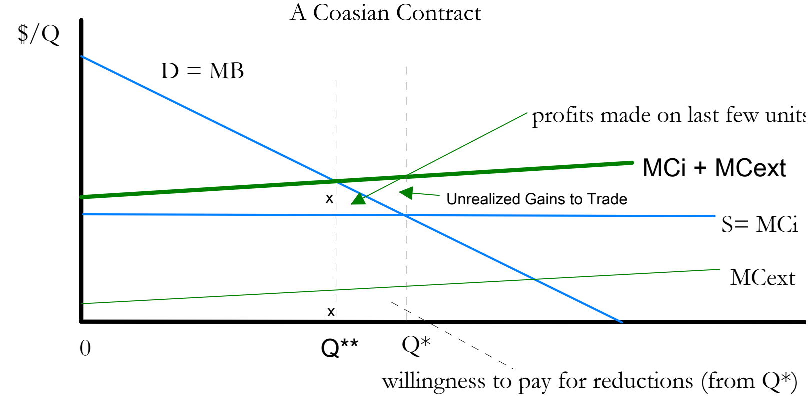
The firm can, thus, compensate the homeowners for the costs imposed on them by its smoke on all units of output up to the point where Acme's willingness to pay for the privilege of producing more output exactly equals the amount required to compensate home owners at Q**.

In the case depicted, the strong form of the Coase theorem holds. The same output level occurs regardless whether the firm or the home owners initially control the emission or output level. (This counter intuitive result is why Ronald Coase won the Nobel prize in economics in 1991.)

(Of course, the flow of payments clearly differs! Acme prefer the first setting, and the homeowner's association prefer the second.)

Figure 3

A Coasian Contract



VIII. Collective Management of Externality Problems: Pigovian Taxes and Subsidies

A. Not all externality problems can be solved with changes in the assignment of property rights or Coasian contracts.

Transactions costs may be very large,

or the resources of interest might not be easily divided up and assigned to specific users.

In such cases, some form of *collective management* will be necessary to address externality problems.

B. There are **many possible collective management solutions** to externality problems.

- Elinor Ostrom (1991) is famous for her efforts to explore and catalog all the institutional solutions devised in the real world.
- That work earned her the Nobel Prise in Economics for 2009--a rare feat for a political scientist.
- We will, however, focus on solutions proposed by economists.

C. Pigovian Taxes, public finance as a method of "**internalizing**" externalities.

i. A **Pigovian tax** attempts to change incentives at the margin by imposing a tax (or subsidy) on the activity that generates the externality.

ii. Notice that if the externality producer bears all the costs associated with his or her activities, they will choose the Pareto efficient level of the activity.

- In such cases, there is effectively no externality, no neglected spillover costs borne (only) by others..

iii. A tax (or subsidy) is said to *internalize* the externality, if it makes the externality producer bear the full cost of his actions (at Q**).

- In principle, Pigovian tax schedules can have a variety of shapes, but for the purposes of this class we will assume that they are all "flat taxes" that assess the same tax on every unit of the product (or emission) produced.
- Pigovian taxes may yield substantial revenues although this is not their main purpose. *Their main purpose is to change behavior.*

D. In Figure 2 below, a typical externality problem is illustrated and then solved using a Pigovian tax.

i. Note that without a Pigovian tax, there are unrealized gains to trade (see triangle UGT) at Q*, between the firm and those affected by the externality.

- (This property is, of course, what made the Coase theorem operate.)

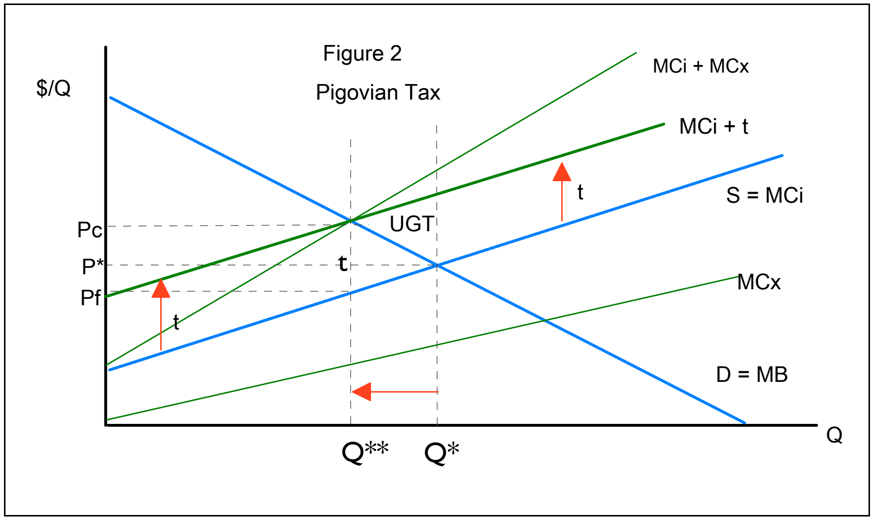
The external cost at Q** is the vertical distance from MC to the MC + MCx curve

This distance also represents the Pigovian tax that should be put on production to internalize the externality.

- The Pigovian tax is labeled "t."

If a tax of t dollars per unit is imposed on the firm's output (or emissions) the firm will now face a marginal cost for production equal to MC + t.

Given this new MC curve (which includes the tax that "internalizes" the externality) the firm will produce an output of Q**, the Pareto Efficient level.



ii. Note that Pigovian taxes allow all firms to independently adjust to the tax, which tends to imply that the burden of a Pigovian tax system is less than that associated with direct regulation.

- This is part of the reason that economists tend to "like" Pigovian taxes.
- They are also relatively easy to adjust if mistakes have been made about G**, and, as we will see next week, they have a relatively low excess. burden associated with them.
- Nonetheless, the tax burden required to achieve the desired level of the externality generating activity can be very large, which tends to make both consumers and firms in the taxed industry worse off.
- This tends to make Pigovian taxes politically unpopular.

iii. Imposing a Pigovian tax requires that the marginal external damages be estimated.

This may be possible at Q* , the output actually produced in the unregulated setting.

However this will be more difficult to do at Q** because Q** is not observed and has to be estimated using estimates of SMC and SMB.

E. Pigovian Subsidies are essentially similar to that of the Pigovian tax, except in this case the externality generating activity is under produced, and the subsidy attempts to encourage additional production.

i. Internalizing the externality in this case requires producers to take account of unnoticed benefits falling on others outside the decision of interest.

ii. [Draw a diagram that illustrates a positive externality and show how a subsidy can be used to induce Pareto optimal levels of the activity of interest.]

IX. The Mathematics of Pigovian Taxation

A. In cases where an externality is generated by an activity, it will often be the case that the activity level will be set at levels that are not Pareto efficient.

B. The easiest way to demonstrate this mathematically is with a two person (group) illustration.

i. Suppose that Al and Bob are neighbors. Both own barbecues, and that neither enjoys the smell of smoke and such associated with the other use of their barbecue. Let us refer to Al as Mr. 1 and Bob as Mr. 2.

ii. Let $Ui = u_i(Ci, Bi, Bj)$ for each person i (here: i = 1, 2) with Ci being food cooked indoors and Bi being food cooked outdoors by i, and Bj being food cooked outdoors by the neighbor ($i \neq j$).

To make the model tractable, assume that Mr. I allocates his "kitchen time" Ti between cooking and barbecuing so that $Ti = Ci + Bi$ for all i.

Mr I's barbecuing time can be determined by maximizing U subject to the time constraint. Substituting, the constraint into the objective function to eliminate Ci yields:

$$Ui = u_i(Ti - Bi, Bi, Bj).$$

Differentiating with Bi yields: $Ui_{Ci}(-1) + Ui_{Bi} = 0$.

- Each person will use the barbecue up to the point where the marginal cost in terms of reduced satisfaction from indoor cooking equals the marginal utility of further outdoor cooking.

iii. The implicit function theorem implies that $B_1{}^* = b_1(B_2, T_1)$.

- This can be interpreted as Mr I's best reply function.

In a Nash game between the two neighbors, equilibrium will occur when: $B_1{}^{**} = b_1(B_2{}^{**}, T_1)$ and $B_2{}^{**} = b_2(B_1{}^{**}, T_2)$

iv. The matter of whether this is Pareto Efficient or not is intuitively obvious. The question is whether or not Al or Bob could be made better off by coordinating their behavior or not.

One way to determine this is to show that a general social welfare function is maximized at by the relevant choices: e. g. whether the first order conditions are the same or not.

- [See above.]

Another method of characterizing the Pareto frontier without using a social welfare function can be taken from Baumol. This requires determining whether one person can be made better off at the Nash equilibrium without making the other worse off.

- For example: maximize $L = u_1(T_1\text{-}B_1{}^*, B_1{}^*, B_2{}^*) - \lambda(U_2 - u_2(T_2\text{-}B_2{}^*, B_2{}^*, B_2))$ by varying B_1 and B_2
- Differentiating with respect to B1 and B2, and appealing to the envelop theorem (to eliminate effects of B1* on B2* and vice versa) yields:
- $U1_{C1}(-1) + U1_{B1} - \lambda\, U2_{B1} = 0$ and $U1_{B2} - \lambda\, (U2_{C2}(1) + U2_{B2}) = 0$
- Note that these first order conditions are different than those met for either person insofar as they imply that the externality will be internalized at the margin for both parties.
- [Draw a diagram of the Nash Equilibrium that demonstrates that too much of the externality generating activity had been produced.]

Note that a tax set equal to the spillover costs, generates the same output as the Pareto efficient one.

- (Once the externality is "internalized" both persons have "best reply functions" that induce the same behavior as required by the Pareto first order conditions.)