

ENVIRONMENTAL AND RESOURCE ECONOMICS

As a field in economic, *environmental economics* is now about 40 years old. The field of *resource economics*, covering water resources, mineral resources, and renewable resources (forests, fisheries) is older, going back in its modern incarnation to the 1950s.

There are about 1000-1200 environmental and resource economists in the United States and a like number in Europe and the rest of the world. The professional organizations are the Association of Environmental & Resource Economists (www.aere.org) and the European Association of Environmental and Resource Economists (www.eaere.org). The first World Congress of Environmental & Resource Economics was held in Venice in 1998; the second was held in Monterey in 2002; and the third was held in Kyoto in 2006.

Environmental economics itself has two main subfields:

1) Economic Approach to Environmental Policy

Determining (i) the appropriate levels of pollution control and environmental protection, and (ii) the appropriate policy tools to achieve those levels

2) Nonmarket Valuation

Assessing, in monetary terms, the economic value of the environment and the loss of economic value from pollution

Note: (2) is a necessary input to (1)

ECONOMIC APPROACH TO ENVIRONMENTAL POLICY

As noted, this involves two sets of issues:

(1) Determining the appropriate levels of pollution control and environmental protection, and

(2) Determining the appropriate policy tools to achieve those levels

Logically prior to these questions, there is an larger issue:

(0) Why *should* there be an environmental policy? Why should the government be asking these questions? Why should the government become involved?

The answer to the last question has to be that there is a problem, something is not working right, and this calls for government intervention.

This line of argument is an application of a branch of economics known as welfare economics. It involves, among other things, a theory of what constitutes a *social optimum* – what type of outcome represents something that is in the best public interest.

Economics provides a specific way of defining what is a social optimum. In fact, it provides several alternative ways of defining this. Later on, I will explain the most common definition, and also offer a critique. But, for now, let me focus on a simplified exposition of the underlying problem that the environmental policy is called on to address.

The underlying issue involves what is know as an *externality*

EXTERNALITY

The concept of an externality was introduced by the English economist Arthur Pigou in 1918 in *The Economics of Welfare*

An externality arises when, by his actions, an individual or entity imposes a cost or benefit on *other* individuals or entities.

To explain this, Pigou introduced the notion of a distinction between the *private* cost (or benefit) of an activity and its *social* cost (or benefit).

The private cost is defined as the cost incurred by the individual or entity that undertakes the activity; similarly, the private benefit is the benefit that accrues to the individual or entity that undertakes the activity.

The social cost includes both the private cost and also the sum of *all other* costs borne by other individuals and entities. Similarly, the social benefit includes all the benefits accruing to other parties.

An example Pigou gave was a railroad. The private cost is the cost of the railroad equipment, the wages for the train engineer, the cost of the coal used to fuel the locomotive, etc. The social cost includes damage to owners of land adjacent to railroad tracks from fires on their land caused by burning embers of coal from the locomotive, or the health costs of the air pollution from the smoke.

Another example illustrated the distinction between private and social benefits. Suppose mothers were able to stay home with their new born children for the first few months after birth (e.g., because either the government or their employers offered this benefit to female employees). Pigou thought that, in the long run, this would make for healthier children and a healthier population than if the mother went back to work immediately, which was a social benefit, quite apart from the private benefit to the mother and her family.

EXTERNALITY

An externality arises whenever there is a divergence between the private and social cost of an activity, or the private and social benefit.

Pigou referred to the difference between the private cost and the social cost of an activity as a *negative externality*, and the difference between the private benefit and the social benefit as a *positive externality*.

Pigou argued that, if significant externalities exist, this is likely to require some government intervention into the functioning of the economy.

EXTERNALITY AND GOVERNMENT INTERVENTION

Pigou accepted that, in the absence of externalities, markets are likely to function in the public interest because decision makers themselves bear the consequences of their actions – they incur the costs and receive the benefits. So, when they act in their own self-interest, they will also be acting in the public interest.

[Note: This is Adam Smith’s “invisible hand” argument, and it requires a definition of the public interest as being identical to some aggregate of individual private interests.]

Pigou’s contribution was to point out that, when there are significant externalities, self-interested private actions will not necessarily be in the public interest because individual decision makers are likely to ignore the external costs and benefits of their actions.

Pollution by railroads is an example where public and private interests diverge. Since the social costs exceed the private costs because of the danger of fire and pollution, there will be too much railroad activity, or at least too little fire- and pollution- prevention activity.

Pigou thus established that, in the presence of externalities, some form of government intervention is likely to be required.

EXTERNALITIES AND MARKET FAILURE

To summarize, when there are externalities, the allocation of resources resulting from a competitive market is not in the best public interest – it is inefficient – precisely because actors base their decisions on an assessment of the private benefits and costs associated with their actions

For an allocation to be in the best public interest it would have to be based on a balancing of social benefits and costs. This doesn't happen because these social benefits and costs diverge from the private benefits and costs and are ignored by actors in the market.

This subsequently came to be called “market failure.” Pigou held that the presence of market failure justifies an intervention by the government.

REMEDIES FOR AN EXTERNALITY

What form should the government intervention take?

Pigou identified two potential remedies:

- 1) The government could regulate those private actions that could cause a negative externality, or it could itself provide services that cause a positive externality.
- 2) The government could impose a tax on activities that cause negative externalities, in an amount equal to the difference between their private and social cost. For activities that cause positive externalities, the government could offer a subsidy in an amount equal to the difference between the private and social benefit. In this way, the externality would be *internalized*. Private decisions by agents in a competitive market would now lead to a socially optimal outcome.

THE AFTERMATH OF PIGOU

At the time, Pigou's analysis was a powerful attack on the conventional wisdom in economics.

It was unusual in making the case for an activist government policy.

The engine that propelled the case for government intervention was the concept of externality.

However, Pigou had defined the concept somewhat imprecisely. His work triggered a wave of analysis in economics aimed at refining and sharpening his analysis in order to clarify the exact circumstances under which government intervention was or was not justified.

In fact, it took until the 1950's before Pigou's analysis was satisfactorily clarified in economics.

THE SEARCH FOR A PRECISE DEFINITION OF EXTERNALITY

In the literature from the 1920s to the early 1950s seeking to clarify Pigou's analysis, several ideas were floated.

Economies of scale and natural monopoly

Economies of scale refers to a feature of production technology whereby the marginal cost of producing a commodity is lower than its average cost (the cost of producing an additional unit is lower than the average cost per unit for all units up to that point). Therefore, it becomes cheaper to produce a good by producing more of it?

Is this an externality? The answer is that it is *not* what underlies Pigou's argument (it is an *internal* economy of scale, not an external economy of scale).

However, this phenomenon does have some implications for policy. It characterizes a situation where perfect competition is not sustainable, a situation of *natural* monopoly.

The Infant Industry Argument

A notion separate from economies of scale is that of “learning curves” and “learning by doing.” This is the notion that production costs will fall as *cumulative production experience* increases, either at the level of the individual firm or the industry.

Therefore, a way to promote a new industry and make it cost-competitive with existing firms in the industry in other countries, say, is for the government to protect or subsidize or otherwise promote the new industry until it can move sufficiently far down the learning curve.

The Big Push Hypothesis

To promote economic development in post-war Europe and in developing countries, the argument was made that the government should provide public infrastructure (railroads) or invest in key industries (steel manufacturing) in order to trigger wider growth in economic activity in rest of the economy.

Whether right or wrong, neither of these is an externality in the sense that Pigou was discussing.

THE FINAL DEFINITION OF EXTERNALITY

The final resolution of what constitutes the sort of externality that causes market failure and generates a case for government intervention did not occur until 1954.

It involves a distinction between a “pecuniary” externality and a “physical” or “real” externality.

Pecuniary Externality

Consider a case where, because I buy chocolate donuts in a such a large volume that I drive up the price of chocolate donuts in Berkeley. You also happen to like chocolate donuts and you are adversely impacted by my action because now you have to pay more for your donuts. Is this an externality a la Pigou? The answer is: no.

This is a pecuniary externality; the interaction occurs entirely through the functioning of economic markets. It is not a source of market failure, and there is no case for government intervention.

Real Externality

The railroad is an example of a real externality, causing fire on adjacent land by the spreading of burning embers, or causing air pollution. These are cases where the actions of one agent *directly* affect the wellbeing (utility) or production of another (as opposed to just the prices that person faces).

It is this type of externality that causes a market failure and justifies government intervention a la Pigou.

REFINEMENTS OF THE EXTERNALITY CONCEPT

As it happens, it was at just this time that there were important other developments in welfare economics, leading to concepts related to the Pigouvian concept of a real externality:

1. The tragedy of the commons
2. Intertemporal externalities
3. Congestion externalities
4. Public good

INTERTEMPORAL EXTERNALITY STOCK RESOURCE

Distinguish three types of stock resource:

Renewable: forests, fishery. Stock is diminished by harvesting, but grows naturally. Annual growth is a function of the stock of resources remaining from the past.

Non-renewable: oil, coal, gold. Fixed stock in ground at any given location. Stock does not grow, and is diminished by extraction.

Groundwater: Stock is diminished by extraction, but can increase over time from recharge. Recharge may in part be a function of water application on overlying land.

A stock resource is where there is an inter-temporal connection: the supply (stock) of commodity available at some future time, $t+1$, say, depends on stock available at a previous point in time, t . This is not true for other (non-storable) commodities.

The inter-temporal connection in supply induces a real, inter-temporal externality.

FORESTRY/FISHERY USER COST AS AN EXTERNALITY

To see the externality, distinguish two types of costs for the harvesting of fish:

- a direct, out of pocket cost (the cost of operating the fishing boat)
- a type of opportunity cost [An opportunity cost is a an implicit or indirect cost when something beneficial is foregone by undertaking an action. The opportunity cost is the benefit foregone.]

What is foregone? What is the opportunity cost. The cost arises from to the stock phenomenon and the inter-temporal linkage in supply.

The key point, here, is that harvest costs at any given point of time are likely to be affected by the size of the current stock: the smaller the stock, the higher the current harvest cost.

Thus, total harvest cost at time t depends on (i) what quantity is being extracted during year t , and (ii) the stock existing at that time.

Depleting the stock in year t (by harvesting) therefore raises the harvest cost in future years. This may be viewed as a social cost but not necessarily a private cost (from the viewpoint of this year's fishermen).

Thus, the full social marginal cost of harvesting a unit of fish this year == the (private) marginal cost of fishing
+ the future increased cost of harvesting with a stock that is permanently reduced below what it would be if one were to abstain from fishing this year.

The latter cost, sometimes known as the user cost, is the component of social cost that is likely to be ignored by fishermen.

To the extent that it is ignored, it leads them to a degree of over-fishing.

NONRENEWABLE RESOURCE

The same story holds for a non-renewable resource, such as coal or oil, when the extraction cost at any given point of time are likely to be affected by the size of the current stock: the smaller the stock, the higher the current extraction cost.

Depleting the stock by extraction therefore raises the extraction cost in future years. This may be viewed as a social cost but not necessarily a private cost.

Thus, the full social marginal cost of extracting a barrel of oil == the (private) marginal cost of extraction
+ the future increased cost of extraction with a stock that is permanently diminished compared to what it would be if one were to abstain from pumping this year.

The latter cost, sometimes known as the user cost, is the component of social cost that is likely to be ignored by oil pumper.

To the extent that it is ignored, it leads them to a degree of over-extraction.

GROUNDWATER

The same story holds for groundwater.

Depleting the stock by pumping therefore raises the extraction cost in future years. [IF THE PUMPED GROUNDWATER IS USED FOR IRRIGATION ON LAND OVERLYING THE AQUIFER, THIS IS PARTIALLY MITIGATED BY RECHARGE FROM THE IRRIGATION, BUT TYPICALLY NOT TOTALLY.] This may be viewed as a social cost but not necessarily a private cost.

Thus, the full social marginal cost of pumping a gallon of groundwater == the (private) marginal cost of pumping
+ the future increased cost of pumping with a stock that is permanently diminished compared to what it would be if one were to abstain from pumping this year.

The latter cost, sometimes known as the user cost, is the component of social cost that is likely to be ignored by the groundwater user.

To the extent that it is ignored, it leads them to a degree of over-draft compared to what would be socially optimal.

CONGESTION EXTERNALITY/ RECIPROCAL EXTERNALITY

Return to a static (non inter-temporal) setting.

In the case of the externality involving the railroad, the externality was uni-directional. There was a polluter (the railroad) and a victim.

Sometimes the polluters are also victims, and vice-versa.

This is the case with congestion. At rush hour, when I decide to drive into San Francisco on the Bay Bridge, I make the bridge more crowded – and increase the travel time and travel cost – for all the *other* people using the bridge at that time.

This is a reciprocal form of externality – I cause an externality for you, when you are also driving across the bridge, and you cause one for me. It is a real externality, not a pecuniary one.

The private cost is my driving cost (gasoline, travel time etc); the additional social cost is the increased cost (gasoline, travel time) for other drivers. I typically focus on the former and disregard the latter. Hence the bridge is overcongested.

Similarly with animal owners grazing a commons. The commons is communally available to all of us. When I graze an extra animal, it reduces the supply of forage for your animals. This is a social cost that I disregard. Hence the common is overgrazed.

REMEDIES FOR THE TRAGEDY OF THE COMMONS

1. Impose a tax on harvesting/extraction in the amount of the user cost (the social cost imposed on others) that will internalize the externality. A fishing tax, extraction tax, pumping tax, grazing tax, or bridge toll that varies with and reflects the degree of congestion.
2. Directly regulate the externality by placing a limit on the amount of harvesting, extraction, groundwater pumping, grazing, or access to the bridge at times of congestion.
3. Create a single owner with sole access to the resource. For example, unitizing the oil field; dividing up the commons and creating privately owned land parcels. The sole owner presumably is mindful of the user cost incurred by his current extraction and lets it influence his decision making – he internalizes the externality.

PUBLIC GOOD vs PRIVATE GOOD

Samuelson (1954) draw a distinction between conventional market goods –also known as *private goods*– and what are known as *public goods*, “which all enjoy in common.”

The two key properties of a public good are *non-rivalry in consumption* and *non-excludability*.

With conventional goods, one person’s consumption necessarily competes with that of another, in that more consumption by one person renders a smaller quantity of that good available for consumption by anybody else (i.e. rivalry in consumption).

With public goods, by contrast, more consumption by one person in no way reduces the amount available for others.

Conventional consumption goods are excludable in that, if this is so desired, it is physically possible to exclude any person from consuming the commodity. With public goods, by contrast, if the good is available for consumption by anybody, it is available for consumption by all.

Examples of a public good are “an outdoor circus or national defense which is provided for each person to enjoy or not, according to his tastes”.

With a public good, there is an externality and a market failure.

PUBLIC GOODS AS A SOURCE OF MARKET FAILURE

Two distinctive economic features of public goods:

- 1) The level of a public good is not determined by individuals acting unilaterally through the market place. Public goods require collective provision. The public may determine this provision, but through voting rather than through their individual purchases.
- 2) It is likely that they will be undersupplied because people have a selfish incentive to free ride on the collective decision process by understating their true interest in the public good.

USE AND NON-USE VALUE

Krutilla (1967) introduced the distinction between use and non-use or existence value of an environmental resource. A person gets a use value from her use of the resource; a person can also obtain satisfaction and wellbeing from knowledge that the resource exists.

I never go to football games, but I can derive satisfaction if Cal has a winning football team and would be willing to make a donation to support this. That is a non-use value, not a use value.

Non-use values are a form of public good.

For example abating pollution in a lake is a public good: my enjoyment of the clean water in the lake in no way reduces the amount of clean water available for your enjoyment (non-rivalry) and, if the water in the lake is clean for me to enjoy, it is clean for everyone's enjoyment (non-excludability).

Hence, the issue of under-supply may arise.

THE STORY AS OF 1959

By the end of the 1950s, the theory of environmental policy seems well developed in principle.

1. *Some* degree of pollution is socially desirable. This is because there are benefits (avoided costs) from permitting pollution, as well as benefits from limiting pollution.
2. These benefits and costs may accrue to different groups of people, but from the social policy perspective all groups should be considered. What matters is the aggregate net impact on people. [THIS REFLECTS DEVELOPMENTS IN WELFARE ECONOMICS STARTING AROUND 1940 – THE KALDOR/HICKS OR POTENTIAL COMPENSATION CRITERION: If the aggregate benefit to the gainers exceeds the aggregate cost to the losers, the policy is in the public interest.]
3. The socially desirable level of pollution balances the social benefits against the social cost; it selects the level of pollution that maximizes the social net benefit.
4. This level is typically where the marginal social cost (damage) of pollution just equals the marginal social benefit (the marginal abatement cost avoided).
5. In the presence of pollution externalities, the market alone will not bring about this optimal level of pollution. Typically, there will be an over-production of pollution. [PIGOU]
6. The government can correct the market failure by regulating pollution generation or by levying a tax on pollution that internalizes the externality. The tax should be set equal to the marginal social damage that occurs at the socially optimal level of pollution. [PIGOU]

THE COASE THEOREM (1960)

Pigou, as subsequently interpreted, emphasizes that (i) the problem arises because of the physical fact that there is a real externality in consumption or production; and (ii) the problem can be solved only by government intervention in the form of direct regulation or a tax.

Coase challenges this.

From a legal perspective, given the existence of tort law and liability rules, why don't the parties litigate?

Two potential liability rules:

The polluter is liable for damages he causes

The polluter is not liable for damages he causes

Coase asserts that, either way – regardless of the liability rule – private negotiation and litigation among the parties should lead to the socially optimal outcome (the Coase Theorem).

IMPLICATIONS OF COASE

1. The Coasian bargaining is impaired if the liability rule is unclear, and/or if there are high transaction costs.
2. The essential problem has nothing to do with the physical production process or the physical nature of commodities; it arises from a social failure, a failure of bargaining.
3. The required remedy is not Pigouvian governmental intervention. Instead, the remedy is for the government to clarify liability rules and reduce transaction costs, and then step aside.

SUBSEQUENT CORRECTIONS TO COASE

It is not true that, regardless of the liability rule, private bargaining and litigation among the parties should lead to the same outcome. At the least, there is a wealth transfer which varies depending on whether the polluter is or is not liable. This makes a difference both economically and, perhaps, from a policy perspective.

In some cases, Coasian bargaining is a non-starter. It is unrealistic if:

- There are many parties on one or both sides. The transaction costs become prohibitive. Moreover, if there are many parties on one side, the outcome may be in the nature of a public good for each individual on the side, leading to the problem of free-riding.
- The parties involved live at different times (today's pollution affects future generations) or for some other reason cannot bargain with one another.
- There is imperfect information. For example, the victims don't know they are being affected, or at least don't know until it is too late.

AN ASSESSMENT

Coase certainly adds another tool to the policymaker's arsenal – the liability approach to pollution control (establish a liability rule and let litigation take care of the problem)).

This also underscores two crucial elements of environmental policy:

- 1 Not everything is an externality that calls for government intervention. One has to decide which externalities are sufficiently important as to justify intervention. That is a value judgment, and a policy judgment; it is not a matter of economics
2. An externality is, above all, a conflict of interest between certain parties. This makes the equity aspect of great importance. I don't see how one can usefully formulate an environmental policy without getting into ethical and value judgments. These form the basis for an economic analysis, but do not come from economics.
3. A large portion of argumentation about environmental policy is actually an argument about setting or resetting the property rights. This is often disguised as assertions regarding economic efficiency, but it rests on implicit choices of property rights. In reality, this is policy/values, not economics.

SUBSEQUENT DEVELOPMENTS

Emission trading

Enforcement and penalty policy

Uncertainty and prices versus quantities

Asymmetric information and mechanism design

EMISSION TRADING

ENFORCEMENT AND PENALTY POLICY

What is the objective?

Economic efficiency

Deterrence

Making victim whole

“PRICES VS QUANTITIES”

ASYMMETRIC INFORMATION AND MECHANISM DESIGN