Chapter

13

Externalities and Environment

The charming landscape which I saw this morning is indubitably made up of some twenty to thirty farms, Miller owns this field, Locke that, and Manning the woodland beyond. But none of them owns the landscape. There is a property in the horizon which no man has but whose eye can integrate all the parts, the poet. This is the best of the men's farms, yet to this their land deeds give them no title.

Ralph Waldo Emerson, *Nature*

Efficient and Equitable Resource Allocation ♦ Property Rights and Private Solutions ♦ Policies for Externalities ♦ Common Property Resources

An externality occurs when an agent's actions affect the production or well-being of third parties without compensation.[1] Such events are common. Many activities affect the environment, which in turn affects the production of other goods or the welfare of individuals. Externalities are also common in urban areas.

The basic cause of externalities is absence of property rights. With property rights, there is no externality. Without, property rights, agents of third party impacts can ignore the impacts and resources are likely to be used inefficiently. Negative externalities are more common than positive ones because the agents have no incentive to avert them whereas agents creating an external benefit may try to collect the benefit. Whatever the nature of the externality, there are potential income or welfare gains from correcting them. Negative externalities are also widely viewed as inequitable. But what are the best outcomes and best policies?

This chapter seeks to answer these questions. We first discuss efficient and equitable outcomes. We then examine the role of property rights in creating and resolving externality problems. There follows a discussion of the main policy instruments for dealing with externalities—market-based instruments and regulations. The last part of the chapter discusses policies for common property resources.

Efficient and Equitable Resource Allocation

In the absence of externalities, resources are used efficiently when the marginal private benefit (MB) from an extra unit of output equals the marginal private cost (MC). When there are externalities, the equivalent efficiency condition is that the marginal social benefit (MSB) from an additional unit of output should equal the marginal social cost (MSC), where social

---

[1] As discussed in Chapter 4, it is important to distinguish between physical externalities where no compensation occurs and pecuniary externalities where people are affected through price changes but there are compensating effects (winners from the changes as well as losers). This chapter deals with physical externalities.

benefit and cost includes the benefits and costs of third parties. If the level of output is such that MSB is greater or less than MSC, someone can be made better off and no one worse off by altering output to the point where MSB = MSC.

Consider first a negative externality. Figure 13.1a shows industry demand and supply curves for coal-powered electricity. In a competitive industry, the supply curve can be interpreted as a marginal cost curve. The MSC curve includes the external damage costs of air pollution. Given a competitive market, the equilibrium output of electricity is Q_M, where MB = MC. Allowing for external costs, the efficient output would be Q_E, where MSB = MSC. A reduction in output from Q_M to Q_E would reduce external damage costs by area *ABCD*. But the area ACD represents a loss of consumer and producer surpluses. So there is a net welfare gain equal to area *ABC*. The increase in price of electricity from P_M to P_E for output Q_E is a transfer payment.

Now consider a positive externality. Suppose that a property owner improves their pastures and reduces soil runoff on adjacent properties. Figure 13.1b shows the marginal private costs and benefits and the marginal social benefit from each hectare of soil improvement, where MSB includes the benefits of the property owner and their neighbours. The equilibrium market output is Q_M. However, the socially efficient level of pasture improvement is Q_E hectares. If the property owner increases his or her pasture improvements from Q_M to Q_E hectares, there is a net welfare gain equal to area *ABC*.

These analyses of efficient resource allocation are accurate, but not complete. Consider the electricity example. Our analysis suggests that the efficient policy is to reduce output of electricity. This is correct if this is the *only* way to reduce air pollution. But if air quality can also be improved by using cleaner coal or by substituting other fuels as the energy source, one or other of these actions may be more efficient than reducing output of electricity.

To obtain the optimal solution, it is necessary to focus on the real issue. Pollutants, such as sulphur dioxides, are themselves commodities. The core efficiency question is: 'What is the efficient quantity of that commodity?' Equivalently, given the quantity of sulphur dioxides in the atmosphere, what is the efficient amount of reduction? An important related question is how best to achieve this outcome?

Figure 13.2 overleaf shows two sets of costs associated with pollution: the marginal damage cost of pollution and the marginal cost of reducing pollution. The damages may

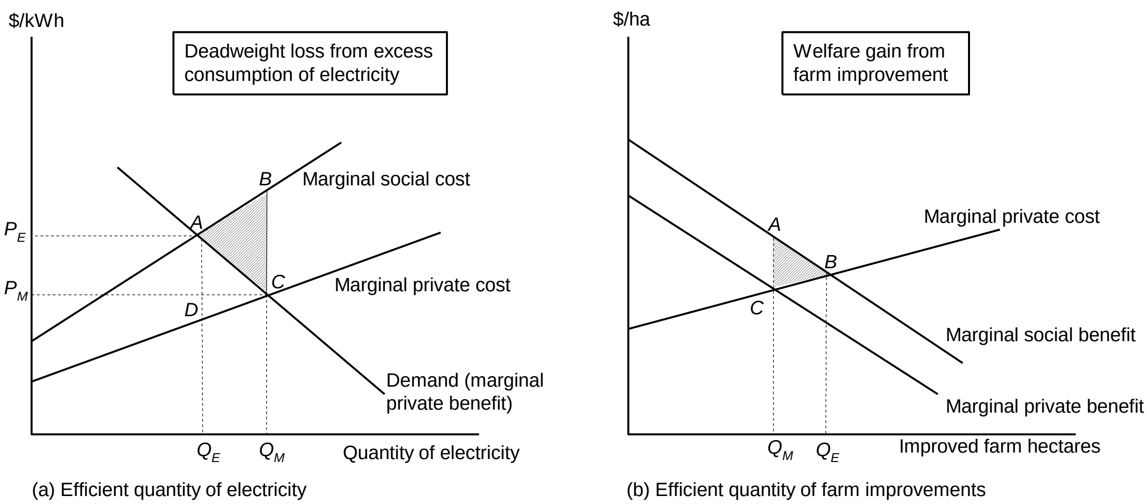

Figure 13.1 Efficient outcomes with external costs and benefits

include losses of productivity, health or amenity.[2] As shown, the marginal damage cost is small at a low level of pollution but increases with pollution. The marginal cost of a small reduction in pollution is also usually low but getting rid of all pollution is expensive. The marginal damage and abatement cost curves may have other shapes, but this does not affect the principle of efficient pollution control. Note also that the areas between these marginal cost curves and the horizontal axis represent total damage and control costs respectively.

Defining the efficient solution as the output that minimises the sum of pollution damage and abatement cost, the efficient amount of pollution is Q_E and the efficient amount of pollution abatement is $Q_F - Q_E$. At Q_E level of pollution, the marginal cost of pollution abatement equals the marginal cost of damages.[3] At higher levels of pollution (i.e. points to the right of Q_E), the marginal damage cost of pollution exceeds the marginal cost of pollution abatement and there is a net benefit from lower pollution. At lower levels of pollution (i.e. points to the left of Q_E), the marginal cost of abatement exceeds the marginal benefit of pollution reduction and it would be socially efficient to have higher levels of pollution.

The solutions in Figures 13.1 and 13.2 are efficient partial equilibrium solutions. They assume that there are no distortions in other related parts of the economy. In the examples above, it is assumed that the prices of the relevant energy resources reflect the marginal social costs of supplying these resources to electricity producers and that there are no unpriced externalities in complementary or substitute markets. If prices in related markets do not reflect marginal social costs, the efficient level of electricity output or the efficient level of pollution abatement may need to be adjusted to allow for these distortions.

In Figure 13.2, is Q_E fair as well as efficient? Any move towards Q_E is potentially Pareto efficient because the gainers can compensate the losers. But, in the absence of compensation, Q_E (and moves towards Q_E) may not be regarded as fair. If the community believes that households have a right to clean air and that firms should pay for polluting the atmosphere, government may decide that more pollution abatement and lower damages are desirable. On the other hand, if pollution controls are likely to result in unemployment, government may

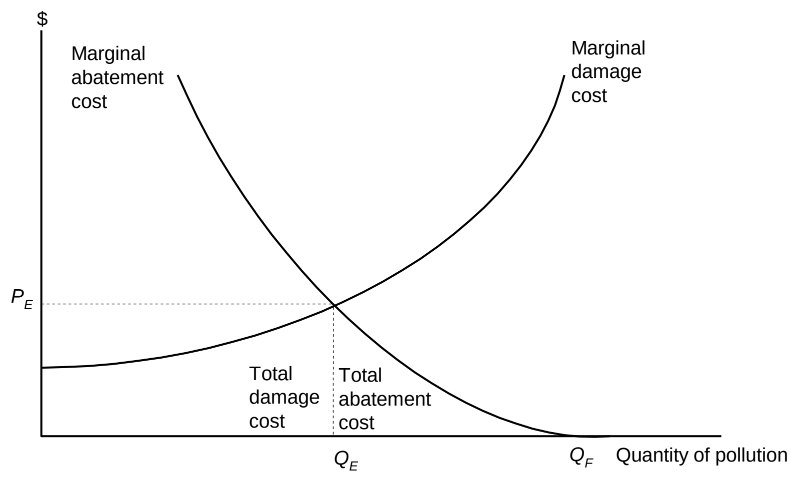

Figure 13.2 An efficient quantity of pollution

---

[2] The analysis assumes that these losses can be valued. Valuation principles are discussed in Chapters 6, 8 and 11.

[3] If the total cost from pollution $TC(P) = C_D(P) + C_A(P)$ where $C_D(P)$ is the damage costs which rise with pollution, and $C_A(P)$ is the abatement costs which fall with pollution, $TC(P)$ is minimised when $\Delta TC = 0$, which requires that: $-\Delta C_D(P) = \Delta C_A(P)$.

decide to allow more pollution than Q_E. Whereas for any given income distribution and set of property rights, and no distortions in related markets, the efficiency outcome is determinate at Q_E, views about an equitable outcome vary with social perspective.

Finally, we note that in the examples above the choice set is continuous and the objective is to choose the optimum quantity of a commodity. In practice, many choices are discrete. Consider, for example, private ownership of guns. The key policy issue is not how many guns an individual can own, but should he or she own any at all, and if so which kind of gun? Or consider a child care centre that may locate in either a residential or a commercial area. The residential location may minimise trip costs of parents but have more negative externalities due to the impacts of motor vehicles and child noise on local residents. In such cases, there is a limited choice set. Of course, decision makers may apply cost–benefit analysis to determine which option maximises net social benefit (although this may have limited application in extreme cases like gun controls). However, when the choice set is discrete, governments typically employ regulations to implement decisions rather than market-based instruments.

Property Rights and Private Solutions

Property rights are central to the analysis of externalities. A **property right** is an entitlement, or bundle of entitlements, defining the owner's rights for use of a resource and any limitations on use. For a property right to be effective, it must be well defined, exclusive, transferable and enforceable. In principle, when property rights are comprehensive, there are no externalities. A property owner can obtain compensation for any damage (providing enforcement costs are moderate). However, if enforcement is costly, a formal property right may not prevent property damage.

Property right
An entitlement defining an owner's rights over resources or assets of various kinds

Given that markets are likely to produce inefficient outcomes when there are externalities, it seems inconsistent to argue that private agents can deal efficiently with externalities. But, in a famous article, Coase (1960) argued that, in the absence of transaction costs, private agents will achieve an efficient outcome (and the same outcome in each case) regardless of the prior distribution of property rights or even without any prior allocation of property rights. This has become known as the **Coase theorem**.[4]

The theorem can be illustrated by an example. Suppose that Cyrus and David own adjacent properties and that Cyrus' farming practices inflict $2 million damages to David's property. Suppose also that by introducing conservation measures Cyrus could reduce damages on David's property as shown in Table 13.1 overleaf. The efficient outcome (the outcome that minimises total damage and control costs) is $0.8 million of conservation expenses, which would leave $0.5 million of damages.

Would David and Cyrus negotiate this outcome? And would the outcome be independent of the allocation of property rights? The answer to both questions is 'yes' if they act to maximise their personal advantage and negotiation is costless. Suppose that neither Cyrus nor David has any formal property rights. If he wished, Cyrus could cause $2.0 million damage to David's property. However, David would be willing to pay $0.8 million for conservation expenditure on Cyrus' property as this would save him $1.5 million in damages. David would also be better off accepting the residual damage cost of $0.5 million rather than pay for more conservation on Cyrus' property. Thus, the outcome would be efficient even if no property rights were specified. Clearly the same outcome would occur if Cyrus was entitled to damage

[4] Coase demonstrated his theorem by examples but did not provide a formal proof. Because of his informal treatment of the subject, several interpretations of the theorem exist. Another way that the theorem may be stated is that, in the absence of transaction costs, all allocations of property rights are equally efficient because the parties will bargain privately to correct any externality.

Table 13.1 Farm damages and conservation expenses ($m)

Total conservation expenses (costs)	*Marginal conservation costs*	*Total damage costs*	*Marginal savings in damages*	*Total conservation and damage costs*
0.0		2.0		2.0
0.2	-0.2	1.5	+0.5	1.7
0.4	-0.2	1.1	+0.4	1.5
0.6	-0.2	0.8	+0.3	1.4
0.8	-0.2	0.5	+0.3	1.3
1.0	-0.2	0.4	+0.1	1.4
2.0	-1.0	0.2	+0.2	2.2

David's property. Now suppose that David is entitled to compensation for any damage to his property. Cyrus must now pay David $2.0 million or adopt conservation practices. Cyrus would minimise his total cost by adopting $0.8 million of conservation and paying compensation of $0.5 million to David. In this example, *the efficient (minimum total cost) result emerges regardless of how property rights are allocated*.

However, the Coase theorem holds only in limited circumstances. These are when (1) the number of parties to the externality is small and (2) the impacts are small and there are no real income effects.

Small numbers are required because an efficient solution will be reached only if the relevant parties are well informed about the costs, do not gain by strategic behaviour or free riding and can reach a solution with limited transaction costs. In practice, externalities often involve several parties, sometimes thousands. Without an organising agency, such as government, it is not feasible for all interested parties to join in negotiations. Free riding occurs because it is in the interest of most individuals to let others organise and pay for the negotiation. Free riding is especially likely when property rights are unclear. Thus, when an externality affects many parties, private exchange generally fails to achieve an efficient outcome.

Income effects can also influence outcomes. As we saw in Chapter 6, when someone holds a substantial property right and expected real income changes are large, the amount that an individual requires as compensation for loss of the property right is often higher than the amount he or she is willing to pay to retain it. This reflects the decreasing marginal utility of income. Loss aversion may also add significantly to compensation requirements. Thus, valuations depend on the distribution of property rights. When income changes are large, the efficient outcome from a property dispute can depend on the distribution of property rights.

For example, suppose that Roger lives in a quiet street and that the local airport authority plans to build a new runway that would cause aircraft to fly low over his house. Suppose further that Roger has no right to the airspace over his house but would be willing to pay $20 000 to stop the planned runway. Although there are many other residents like Roger, their combined payments would not cause the airport authority to change its plan. On the other hand, if Roger has a right to the airspace over his house, the airport authority must compensate Roger for his loss of quiet. Roger may require a larger figure, say $30 000 as compensation, which is the amount that together with the noise overhead would make him no worse off than at present. Given the compensation payable to Roger and his neighbours, the airport authority would now look for another (lower cost) way to enhance airport capacity.

In summary, in simple cases involving only a few parties private exchange can achieve an efficient use of resources even in the absence of property rights (see Box 13.1). Also, when changes are small the outcome does not depend on the allocation of property rights. However, the allocation of property rights may affect the outcome because of income effects. In the

Box 13.1 Summary of conclusions on private exchange

No. of entities	*Size of change*	*Outcome of private exchange*
Very few	Small	May be efficient and independent of property rights
Very few	Large	May be efficient but outcome depends on distribution of property rights
More than a few	Small or large	Outcome indeterminate; likely to be inefficient and may depend on distribution of property rights

more common cases, when more than a few parties are involved, it is difficult to obtain an efficient outcome by private exchange because of high transaction costs, free riding and other strategic behaviour.

Policies for Externalities

Well-defined enforceable property rights increase the range of externality issues that can be resolved efficiently by private actions, if necessary supported by the courts. Advantages of a general property rights strategy are that a harmed party has an interest in obtaining compensation (and so ensuring that harm does not occur) and more knowledge of the damage sustained than government does.

However, reliance on property rights has two main limitations. First, legal processes are not necessarily efficient. Legal processes are often costly and may deter individuals from taking legal action. And, even if the criteria dealing with property damage appear to be clear, judicial interpretations are often unpredictable. Second, if many parties are involved, free riding remains a problem. It pays some people to let others file suit first and to await the outcome. In complex situations, like urban land use planning decisions where many parties are involved, it is unrealistic to expect private exchanges to produce an efficient outcome. Given these limitations, other instruments for dealing with externalities are needed.

The two main strategies for dealing with negative externalities are market-based instruments (MBIs) and regulations.[5] MBIs work through market prices or quantities. For example, a tax raises prices and reduces consumption. MBIs are also called economic instruments. Regulations control the behaviour of firms or households directly. Most governments rely more on regulations than MBIs. However, most regulations have to be supported by financial penalties so that the distinction between a regulation and an MBI is not always a clear one. We focus below on policies for negative externalities, with a brief addendum on positive externalities.

Market-based instruments

MBIs aim to align individual and social objectives by internalising externalities. Internalisation occurs when an agent bears the costs that he or she causes. Thus, MBIs are implicitly a property right strategy. If damage costs are internalised there are no externalities and competitive markets can operate efficiently. The most important MBIs are taxes on products that create externalities or on externalities themselves and quantity controls.

A corrective tax
A tax levied on a market activity that generates a negative externality

Taxes and subsidies for externalities. A tax levied on a market activity that generates negative externalities is generally called a **corrective** or **Pigouvian tax**.[6] To produce an efficient outcome, the tax should equal the *marginal* damage cost *at the efficient level of*

[5] Government may also exhort firms and households to behave in a socially responsible manner, but this tends to be a complementary rather than a primary strategy.
[6] Arthur Pigou (1920) is credited with initiating the concept of such a corrective tax.

output of the good or externality. For example, in Figure 13.1a, firms would be charged a tax equal to *AD*, which is the marginal damage cost at the efficient Q_E level of output of electricity. In Figure 13.2, there would be a tax (emission charge) of P_E per unit of pollutant emitted. However, as we have seen, it is generally more efficient to tax the pollutant itself rather than the good that produces it.

A Pigouvian tax (levied at the appropriate level and on the appropriate target) is efficient for two reasons. First, it encourages firms to produce *a socially efficient level of the pollutant*. The marginal damage charge becomes part of a firm's marginal costs. Firms will reduce pollution so long as the cost of reducing pollution is less than the charge. Thus, in Figure 13.2, firms will reduce pollution to Q_E because, at higher pollution levels, the cost of pollution abatement is less than the emission tax. A lower tax produces too little pollution abatement. A higher tax encourages too much abatement.

Second, marginal damage charges encourage firms to achieve the efficient level of output *at least cost*. For example, a tax on emissions allows each firm to determine how to reduce emissions in the least-cost way. Firms that can reduce pollution most economically do so. A Pigouvian tax provides a continuous incentive to firms to adjust their output or methods of production wherever adjustment costs are less than the tax. Of course, this assumes, and this is a big assumption, that the corrective tax is well designed. Box 13.2 discusses some aspects of an efficient tax on greenhouse gas emissions.

In addition, it is sometimes argued that corrective taxes have a double dividend. Nearly all taxes affect behaviour and have a deadweight loss. This means that the real cost of a marginal dollar of public revenue collected is greater than $1.00. If government revenue is fixed, revenue from corrective taxes can lower other marginal tax rates. In this case, a Pigouvian tax

Box 13.2 A tax on greenhouse gas emissions

The Stern Report (2006) described climate change as 'the greatest market failure the world has seen'. How then should governments deal with greenhouse gas emissions?

One approach is to levy a tax on greenhouse gases, such as carbon dioxide (CO_2), which reflects the marginal damage per unit of emissions. However, estimates of the present value of the stream of future global warming damages per tonne of CO_2 vary widely. According to Nordhaus (2007) the median estimate of marginal damages is between US$30 and US$40 per tonne of carbon emitted, which is equivalent to US$7 to $10 per tonne of CO_2 emitted. Note that one tonne of carbon is equivalent to about four tonnes of CO_2. But these estimates appear lower than those of other experts. Estimated damage costs are very sensitive to assumptions about climate change.

An efficient carbon tax would be levied at the same rate in all countries because all unit emissions of CO_2 cause equal marginal global damage. This would create an incentive to reduce emissions when the marginal control cost is less than the marginal damage. Such a uniform global CO_2 tax would reduce worldwide CO_2 emissions at least cost because the reductions would be made by firms and households when the costs of doing so were less than the carbon tax.

A fully tradable set of carbon permits would also be cost-effective because firms that could reduce CO_2 emissions most cost-effectively would do so and firms that could not do so would purchase permits.

On the other hand, direct government investment in carbon reducing technology is likely to be fiscally costly and inefficient without competitive market disciplines.

However, there are problems associated with a tax on CO_2 emissions. Practical problems arise because countries have widely different taxes on fuels so that it is hard to identify a CO_2 tax element and equalise it over countries.

On the other hand, a unilateral CO_2 tax may have little effect on worldwide emissions and global warming and risks putting a country at a competitive disadvantage.

In Australia, the government legislated that from July 2012 facilities emitting more than 25 000 tonnes of CO_2 would pay $23 per tonne of CO_2 or the equivalent amount of nitrous oxide or methane emitted. This applied mainly to miners and electricity producers with agricultural activities largely exempt. Some fiscal measures were introduced to compensate low income households from rising costs.

However, the government repealed the scheme as from 1 July 2014 and replaced it with The Emission Reduction Fund in December 2014, which was designed to fund public investment in renewable energy with only modest CO_2 emission reduction targets.

would both correct a market distortion and reduce distortions from other taxes. But this ignores the possibility that a corrective tax may also have a distorting effect on labour supply.

Subsidies for pollution reduction can also produce an efficient level of emissions! A subsidy of $*X* per unit of emission reduced has a similar short-run incentive effect to a corrective tax of $*X* per unit of emission. Indeed, governments sometimes employ subsidies to encourage firms to introduce pollution controls, especially when old plants may not be viable with high new expenditures and employment is a concern.

However, subsidies for pollution reductions have two main disadvantages. First, they may encourage firms to enter the industry and under-invest in pollution control technology to gain a subsidy. Second, subsidies change the distributional effects—taxpayers bear the cost of controlling the damages rather than the firm. This may well be viewed as inequitable.

Quantity controls and market creation. With Pigouvian taxes, government sets prices and the market provides efficient quantities. Alternatively, government may set a total tradable quantity (or quota) for a commodity and markets establish the price per unit. For example, in Figure 13.2 a regulator would establish the efficient ambient quantity of the pollutant (Q_E) and the market would set the price per unit of pollutant. In some cases, this may mean creating a market. Like an appropriate Pigouvian tax, setting an efficient tradable quantity will produce an efficient outcome (i.e. an outcome that maximises net social benefit).[7]

Tradable emission permits are an example of this approach. The regulator determines the total quantity of emissions to be permitted. Firms are allocated, freely or by sale, permits that control the quantity of their emissions. Importantly, firms can trade these permits.

In the absence of trading, the permits are essentially a form of regulation which, as shown below, tends to be a more expensive policy. The demand for permits in conjunction with the regulated supply determines the price of the permits (see Figure 13.3). A tradable permit

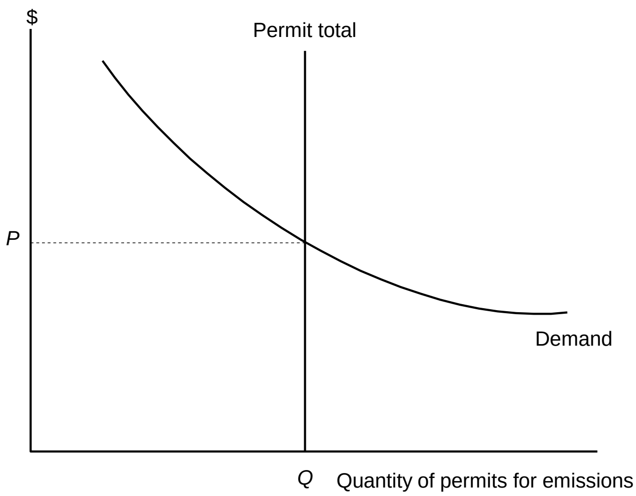

Figure 13.3 Creating a tradable permit market

---

[7] This assumes that government is certain of the marginal benefits and costs of the policies. Rosen and Gayer (2014) show that if there is uncertainty, the preferred instrument depends on the circumstances. When the marginal social benefit (MSB) of pollution reduction is inelastic and the marginal cost (MC) of pollution reduction turns out to be higher than expected, a tradable quota is more efficient. If the MSB is pollution reduction is elastic and the MC of pollution reduction is higher than expected a Pigouvian tax is more efficient. However, this seems to assume that the policies cannot be adjusted to meet changes in knowledge.

system has several advantages. First, unlike a corrective tax, it directly controls the quantity of pollution. Second, like an emission charge but unlike regulations, in a competitive market tradable permits produce a given reduction in pollution at least cost. Firms with low control costs introduce control first and sell permits to firms with higher control costs. Firms with high control costs can operate by purchasing permits without being subject to costly regulations. Third, there is a continuous incentive to search for ways to reduce pollution. Tietenberg (2006) reports that trade in emission permits reduced the costs of complying with the *US Clean Air Act* by over $10 billion compared with a regulatory approach in which all plants would have been required to achieve the same standard of output for emissions.

However, tradable permits work well only if the traded unit is well designed and standardised for marginal damage effects. Problems arise if the units have different damage effects because, for example, emissions of sulphur dioxides create more damage in some areas than in others.[8] Also, a sophisticated monitoring process, often involving significant transaction costs, is required to validate trades and ensure that conditions in the permits are observed.

Examples of market-based instruments. Governments employ a variety of MBIs. These include Pigouvian taxes on negative externalities such as waste emissions or effluents and trading permit schemes. Taxes on polluting products, for example petrol and diesel, energy products, fertilisers and pesticides, batteries and non-returnable containers, are more common than emission taxes. Product taxes are easier to administer but may produce less efficient outcomes. Tax differentiation is a related strategy. In some European countries cleaner cars attract lower sales taxes or registration fees. They also tax unleaded petrol more highly in order to encourage use of unleaded petrol. Deposit refund schemes impose a surcharge on the price of products with waste costs. The surcharge is refunded when the waste product is returned. Deposit refunds have applied to beer and soft drink bottles, other containers, batteries and even cars. Box 13.3 provides examples of these and other MBIs employed in OECD countries.[9]

Box 13.3 Examples of market-based instruments in OECD countries

Sweden is a leader in environmental charges. It levies taxes in the energy sector on oil, coal, natural gas and liquid petroleum gas, and in the transport sector on gasoline, diesel and domestic air traffic. In 1992 Sweden introduced a nitrogen oxides emission charge on large energy sources, which covered some 120 heating plants and industrial facilities with 180 boilers. Today, among OECD countries, Sweden has the highest tax rate on NO_x emission, followed by Norway and Italy. Few other countries have a significant tax on NO_x emissions.

Sweden also has a sulphur tax and a carbon tax. And Sweden levies special charges on nitrogen and phosphate fertilisers and another on acreage of land treated with pesticides.

France has introduced charges on the sulphur content of fuels and announced plans for nitrogen oxide and sulphur dioxide taxes.

Most countries have landfill charges for household waste. Austria, Denmark, the Netherlands, Norway, Sweden and the United Kingdom have especially high landfill charges.

Germany, France and Austria have introduced charges, levied on producers, to control packaging wastes. Many countries employ deposit refund schemes for bottles and aluminium cans. Norway, Sweden and Germany have extended the system to car hulks.

In 2002 the Irish government introduced the Plastic Bag Environmental Levy. Retailers were charged 15 cents per plastic bag, which they were required to pass on to consumers. The number of plastic bags used fell by over 90 per cent in one year.

---

8 The same is true for Pigouvian taxes that should reflect marginal damages rather than emissions regardless of location.

9 For further details of environmental taxes in OECD countries, see <www2.oecd.org/ecoinst/queries/index.htm>.

Regulating externalities

Governments employ numerous regulations to deal with negative externalities. Examples include prohibiting firms from discharging toxic waste into public places, setting fire codes for buildings to protect public safety and regulating driving speeds and amounts of alcohol that may be drunk before driving. Government may also prohibit individuals from owning certain types of guns or from smoking in aeroplanes and pubs. Local government typically regulates land use in some detail.

Regulations are of three main kinds. First, government may **regulate the activity** that creates the negative externality. Examples are restrictions on uranium or sand mining or use of sensitive wilderness areas for tourism or hunting. Such controls are appropriate when the damage is severe and all levels and methods of exploiting the environment are likely to be harmful. But when an activity has multiple outputs, it is generally preferable to focus on the output that creates the damage rather than to regulate the whole activity. Activity regulation is generally inappropriate if the problem is not severe and other methods of regulation are available. For example, it would generally be inefficient to regulate output of electricity in order to control air pollution if alternative pollution abatement actions were available.

Second, government may **regulate production processes or inputs**. Such regulations prescribe how output is produced. Examples are requirements that power-generating plants use only prescribed grades of coal, that industrial plants have effective scrubbers and other pollution control devices, or that smokestacks be a certain height. Controls over the location of industry (land use zoning) are another common form of input control.

Third, government may **directly regulate the externality**. A common example is an emission standard. This is a legal limit on the amount of a pollutant that an individual source may emit. Emission standards are widely used for industrial discharges to water or air and for automobile emissions.

Regulation of the externalities themselves has several advantages compared with regulation of production processes. First, it directly addresses the problem. For example, emission standards deal directly with the quantity of industrial wastes. Second, it allows each firm to decide how to deal cost-effectively with the problem and the firm is likely to know how to do this better than the regulator. Third, controls over production processes work only if plant and equipment are maintained adequately. This is often not the case. However, governments often think that it is easier to monitor production processes than emissions. Accordingly, they often adopt process controls.

Regulations compared with MBIs. Regulations have several advantages compared with MBIs. They are usually practical. They deal well with discrete problems like gun ownership or protection of endangered species. They can deal specifically with the problem that needs to be addressed. Moreover, in principle they can provide an efficient outcome. For instance, an efficient level of some environmental attribute. In addition, for some externalities, such as conflicting land uses, disposal of toxic wastes and control of gun ownership, there may not be a feasible MBI alternative.

However, regulations also have significant weaknesses. First, to determine an efficient outcome the regulator must be aware of marginal costs and benefits with limited or no access to price information. This is unrealistic. Consider, for example, emissions to the atmosphere. An efficient overall level of environmental quality requires an efficient emission standard for each plant which may vary by plant and location. To achieve this by regulation the regulator must know the marginal savings in damage costs and the least-cost method of abatement for each plant. But the regulator cannot know all these data. Moreover, firms have no incentive to disclose their production costs. A regulation that requires all firms to achieve the same environmental standards is highly unlikely to be cost-efficient. Second, regulations are usually a crude instrument and provide crude incentives. If a firm satisfies a regulation, such as an emission standard, it has no incentive to adopt more cost-effective technologies and reduce damages any further. Jorgenson and Wilcoxen (1990) estimated that environmental regulations on 35 industry groups reduced the national product in the United States by 2.6 per cent. As shown in Box 13.4, regulations often fail to produce a cost-effective reduction in pollution.[10]

Moreover, regulations must be supported by penalties, most often by financial penalties. For most breaches of regulations imprisonment is too severe a penalty. However, if the fines are low, regulations are disregarded and ineffective. To be efficient, the fines must reflect at least the marginal damage cost at the efficient level of output. But these fines are equivalent to efficient emission charges! In practice, many countries impose low fines for infringing emission standards (China being a prime example). Firms then choose to pay the fine rather than meet the standard. Occasionally penalties are much higher than marginal damage costs. For example, factories may have to close if they do not meet an emission standard although closure costs exceed marginal damage costs.

Equity issues

Policy makers often want to know the equity implications of alternative policies. These implications are often difficult to determine. Here we mention three significant complications.

First, there is a common presumption that one or more parties create the externality and that other parties bear the costs. However, this implies that there are established property rights. Suppose that there are two parties, *A* and *B,* where *A* is perceived to be the polluter and *B* the damaged party. The damages occur only because of *B*'s claims of a property right. Externalities are bilateral. Without *B*, there would be no externality. Suppose that A is farming some land without neighbours and that *B* moves into part of the area damaged by A's farming practices. Arguably, *B* has created the externality. Or suppose that aircraft are flying harmlessly over farmland, which is turned into urban housing. Arguably the new residents

Box 13.4 Cost of regulations for air quality

The standard policy-making approach to stationary sources of air pollution is (1) to select an appropriate ambient standard for each major pollutant, for example sulphur dioxide, averaged over a specified period and (2) to select emission standards for each major source that will satisfy this ambient standard. The emission standards are generally imposed on several specific emission points, stacks, vents, etc. The time may be defined over a long period such as a year or a short period like three hours.

Usually similar ambient standards must be met everywhere although monitoring is done in specific locations. Emission standards may vary with plant, with allowance for age. New plants are often required to meet the lowest achievable emission rate (regardless of benefits) but this is not a fixed amount as 'achievability' depends on the costs of new technology that may not be proven.

The regulatory approach used to control air pollution in most countries is emission standards. But emission standards often fail to produce the required ambient standards at least control cost. Studies in the United States have found that abatement costs are 70–80 per cent higher under the mandated emission standards than they would be if the least-cost control methods had been adopted (Tietenberg, 2006, p. 379). This is because the emission standards for each plant do not vary sufficiently. Plants where it is costly to abate pollution must achieve similar standards to those that can reduce pollution at low cost. Also, standard emission controls set only a maximum level of emissions. There is no incentive to do better than the regulated emission level.

[10] Despite these disadvantages of regulations governments often prefer to regulate because regulations are easier to understand and appear easier to implement. A public choice explanation for the preference for regulations is that regulations create more work for public servants.

have created the noise nuisance externality. Evidently it may be unclear as to who creates and who bears a negative externality. Attribution of responsibility may be a political judgement and may have a strong bearing on how policy makers decide to deal with any individual situation.

Second, although externalities are not traded directly, markets often create implicit trades in externalities. For example, environmental externalities are traded indirectly when people buy houses. House price differentials reflect environmental qualities. Households pay a quantifiable premium for the environmental attributes of a house and its location. This is efficient because households buy the amount of the externality (e.g. air quality) that they want. It is equitable because households buying into environmentally disadvantaged areas are compensated by lower prices.

Third, externality policies often have many economic effects, again through market mechanisms. For example, policies that require firms to introduce controls to reduce pollution generally increase production costs and reduce output. These costs may be borne partly by consumers due to higher prices, by the shareholders owing to lower profits and by employees in the form of lower wages or employment owing to the lower demand for labour. The outcome will depend, *inter alia*, on the elasticity of demand for the relevant commodity and the ease with which the factors of production can move to other employment.

To develop equitable policies, it is necessary to establish who is creating and bearing the negative externality, whether those bearing the costs are compensated by market mechanisms and how policies dealing with externalities may impact on various social groups. There is no simple prescription for dealing with these equity effects. They have to be established on a case by case basis.

Positive externalities

Goods that have widespread positive externalities, such as public health, are treated in this text as public goods. When positive externalities are more limited, they may be treated more specifically as externalities. Examples of such goods include specialised training courses, in-firm research and development activities, farm conservation practices and property renovations. Each of these may provide beneficial third-party effects. Of course, the difference between a public good and a good with a more limited positive externality effect is one of degree rather than a firm distinction.

We have seen that goods with positive externalities are usually under-supplied in the market. Efficiency requires that output should be expanded to the point where the marginal social benefit of the last unit of output equals the marginal cost. There is therefore a *prima facie* case for public support for more output of these goods.

The most common way to achieve this increase in output is by subsidy, either by way of a grant or a tax concession. To be effective, the subsidy must relate to the firm’s marginal operations or a household’s marginal choice. To achieve an efficient level of output the subsidy should equal the marginal external benefit at the efficient output level.

In practice, the marginal impact of a subsidy is difficult to assess. The Australian government has provided substantial subsidies to industry research and development (R&D) activities, usually by way of tax concessions. However, R&D is difficult to define. It also seems likely that a high proportion of the R&D expenditure that received tax concessions would have occurred in any case without the concessions. Similar issues arise with assistance in any sector, for example with the provision of assistance to farmers for soil conservation. A subsidy may simply support ongoing soil conservation activities rather than generate new ones.

In summary, positive externalities justify public support for certain activities by firms and households. However, efficient and effective public support means identifying and targeting the marginal external benefit. This is not easy to achieve.

Common Property Resources

Common property resources (or common-pool resources) are another example of poorly defined or defended property rights. The term 'common property resources' denotes resources to which any party has free and unrestricted access.[11] Because of the unrestricted access, the users do not have adequate incentives to look after the resource. Consequently, the resources are over-exploited.

Common property resources can occur in conjunction with various legal concepts of ownership. The main relevant legal concepts are: *res nullius*, *res communes* and *res publicae.*

Res nullius denotes a regime in which no one owns or exercises control over the resources. Access is unrestricted and on a first-come, first-served basis. This occurs more often in traditional societies than in modern economies. However, surfing waves might be regarded as a modern example of *res nullius*. ***Res communes*** means formally private property owned by more than one individual. In economic and legal literature, common property tends to mean property jointly owned and managed by a group of people rather than by a few individuals. The co-owners may have formal legal or traditional property rights to the land. Common property regimes encompass a variety of access entitlements. For example, in Switzerland the Alpine meadows have been treated as common property for hundreds of years. An association of users has established members and agreed grazing rights and responsibilities. In effect, there are exclusive property entitlements. However, in other communities there is largely unrestricted access to community-owned land. For example, in the Western Highlands in Kenya, there is generally free access to the forests owned and controlled by the traditional groups. ***Res publicae*** refers to property owned by the state on behalf of the public. Public parks and beaches along with maritime resources are examples. In the United States, over 40 per cent of the land is owned by the state. The state is also a large landowner in Australia. When the state owns the land, it can restrict access. But, typically, access will be restricted only if government ensures this through policy making.

Free (unrestricted) access to resources occurs most often with *res nullius* or *res publicae* but can also occur with *res communes*. A key attribute of common property resources is that use of them is rival. One agent's use of the resources reduces the availability of the resources to other agents. Thus, the economic literature generally treats common property resources as an externality issue rather than as a public good.

As we saw in Chapter 4 with overgrazing of the village commons, common property resources tend to be misused because private interests diverge from social interest. The exploitation of scarce animal resources such as the African elephant or rhinoceros is a popular example of this problem. In Australia, surfers crowd each other out on good surf waves. Similar issues arise with any valuable common property resource unless there is some form of group ownership and control. Without appropriate policies, firms or individuals have little incentive to use these resources in a socially responsible way. The main issues and policy responses are illustrated below in the discussion of common fishery resources.

Common fishery resources

Two main problems occur with common fishery resources and both lead to over-exploitation of the resources. The first problem arises because the private revenue of the marginal fishing group exceeds the social revenue. Suppose that 10 fishing groups catch 10 000 tonnes of fish in a season and catch, on average, 1000 tonnes. Now an eleventh group, with similar technology, enters the fishery and the total catch rises to 10 500 tonnes. The average catch falls to 955 tonnes. This allows each group, including the new one, to cover their costs.

[11] In the economics literature the term usually applies to resources employed in production. But it could also apply to environmental amenities like air and water.

However, the marginal revenue from 500 tonnes would not cover the marginal costs of the eleventh group and there is excessive use of resources in fishing.

This scenario is illustrated in Figure 13.4a. Note that the unit on the horizontal axis is fishing hours (a measure of labour input). The marginal cost of a fishing hour is assumed constant. Given a constant price for fish, the average revenue curve reflects changes in the average product per fishing hour. Average product and revenue per fishing hour fall as fishing hours increase, as more labour chases a fixed stock of fish. Marginal revenue is less than average revenue because marginal product is less than average output. This occurs because fishing is a rival activity. The introduction of an extra fishing group reduces the catch of the existing fishing groups. Total fishing hours will be Q_M, where average revenue equals marginal cost. But the efficient quantity of fishing hours would be Q_E, where marginal revenue equals marginal cost. As fishing hours increase beyond Q_E, marginal revenue is less than marginal cost and resources are employed inefficiently. The deadweight loss is the excess of marginal cost over marginal revenue.

The second cause of overfishing is the lack of property rights over the future fish stock. Each fish has a breeding value as well as a current consumption value. The breeding value of the whole stock is the present value of the net benefit from the future catch. For small fish, breeding value exceeds consumption value. Each fishing group obtains the consumption value of fish that it catches but only a small part of the breeding value of fish it leaves behind. Thus collectively they over-exploit the fish stock. This is illustrated in Figure 13.4b, which allows for loss of fish stock. The social cost of fishing is the cost of fishing plus the loss of breeding value of the fish stock. The efficient level of fishing is Q^* rather than Q_E. At this point, the marginal revenue from the last fish caught just equals the marginal social cost of the catch.

The efficient level of fishing can be achieved using one of the two major instruments previously described: corrective taxes or quantity controls. A tax on the fish catch would raise the price of fish and reduce the consumption of fish and therefore the amount caught. Referring to Figure 13.4b, to reduce the fish catch from Q_M to Q^* government would need to impose a tax equal to $(P^* - P_M)$.

Alternatively, government can establish a total fish catch quota of Q^* to be allocated to fishermen. If this allocation is auctioned, the price for a permit to catch fish would be similar

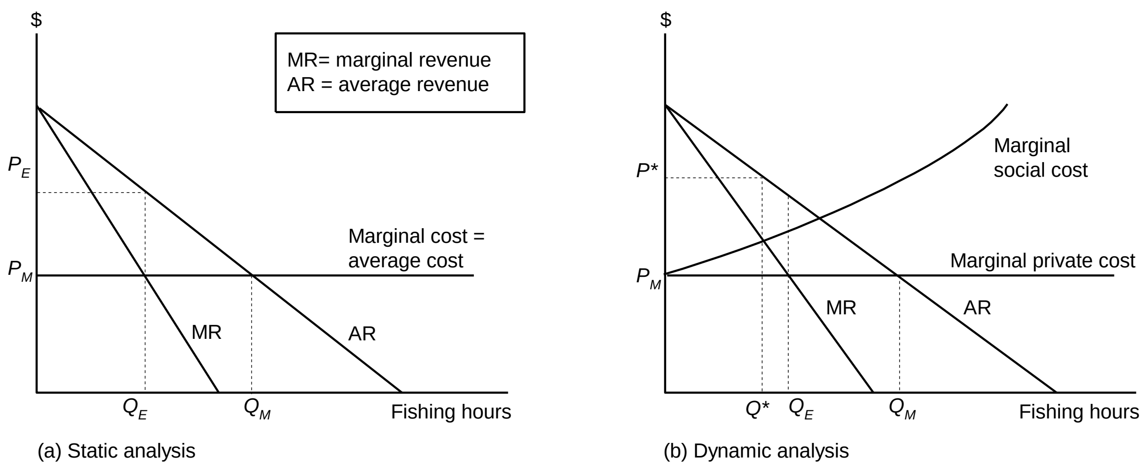

Figure 13.4 Efficient exploitation of a fishery

to an efficient tax, and the revenue would again accrue to government. From an efficiency perspective, the method of allocation is not important; individual quotas can be given away. What matters is that the quotas can be traded and the efficient price established. This ensures that the quotas are owned by the most efficient fishing groups, who will achieve the total quota at least cost.[12] Several countries, including Australia and New Zealand, have adopted quota controls on the fishing industry.

The outcomes of the tax and quota instruments are similar. The quantity of fish caught is reduced by similar amounts. Both policies are more efficient than regulatory policies that control the fishing process such as shortening the fishing season or limiting the size of fishing nets. These regulatory policies can reduce the quantity of fish caught, but they require the fishing industry to adopt high-cost and inefficient fishing practices.

Conclusions

In some cases, commonly owned resources are used harmoniously and efficiently. In 2009 Elinor Ostrom was awarded the Nobel Prize in economics for her case studies showing that many communities have adopted rules and enforcement mechanisms that enable them to manage common-pool resources cooperatively and sustainably. For theoretical support, Ostrom has drawn on game theory which shows that participants tend to be more cooperative in repeated games (Mailath and Samuelson, 2006). Evidently group ownership and management of common property resources can work in some cases. However numerous exceptions can also be found in under-managed game parks in Africa, in the forests of Amazonia and in many fisheries around the world.

When common property resources are over-exploited, government intervention is often desirable. This generally means establishing either property rights, or at least entitlements, to access the resources. When property rights are fully established there are no externalities. The owners have an incentive to use the resource efficiently, by producing up to the point where marginal revenue equals marginal cost, and by conserving the capital value of the resource when the discounted value of future output exceeds present output value. This may mean privatisation of the resource—converting common property into individual title, as occurred with the widespread property enclosures in England in the 17th century. However, dividing large common property resources into private ownership may not be practical or equitable. Therefore, the English enclosure movement allegedly made the workers worse off because the capitalists appropriated more than the gains that the enclosures generated.

When privatisation is not appropriate, the government or the community needs to establish clear rules for access to the resource. Tradable permits provide an efficient way of controlling use of a common property resource. Taxes on output are also an efficient way to control output. Other policies are possible but are generally less efficient than these market-based instruments.

However, as has been stressed throughout this book, market failure is a necessary but not sufficient condition for government intervention for efficiency objectives. Policies are only as good as their implementation. And most policies have transaction costs. These factors need to be considered in assessing government policies for externalities as for other situations.

[12] Of course the method of allocating quotas has significant distributional consequences.

Summary

- An externality occurs when an activity creates a cost or benefit without compensation to an external party that is not actively involved in the activity. Such an externality occurs because of an absence of property rights.
- Externalities almost always represent an inefficient use of resources.
- Resources are allocated efficiently when the marginal social benefit of an action equals the marginal social cost inclusive of any third-party effects. However, optimal resource allocation may also depend on equity considerations.
- When only a few parties are involved, private exchange can deal with externalities and produce efficient use of resources even in the absence of property rights. Private exchange does not produce an efficient outcome when there are many affected parties, high transaction costs and incentives to free riding.
- The two main kinds of policy instruments for dealing with externalities are market-based instruments (MBIs) and regulations.
- MBIs are based on the concept of creating and monetising property entitlements. The main MBIs are corrective taxes (or subsidies) and quantity controls. The efficient tax is equivalent to the marginal damage cost at the efficient level of output. Well-designed MBIs achieve an efficient outcome at least cost.
- Regulations may control activities, production or unwanted externalities themselves. Regulations are practical. However, they are usually a relatively costly way to achieve any given objective.
- Common property resources are resources to which anyone has access. Such resources are often over-exploited. Policies again include establishing property rights, setting prices to reflect marginal damage costs and quota systems.
- However, here as elsewhere, market failure is a necessary but not sufficient condition for government intervention for efficiency reasons. Policies require careful construction and may have significant transaction costs.

Questions

1. Why may the allocation of property rights not affect the allocation of resources even when there appear to be significant externality effects?
2. What should determine the efficient level of output in an industry that produces a polluting product? How would deadweight losses be estimated when this output is not achieved? Explain how distortions in other markets might affect the efficient outcome in the original market.
3. Explain why the optimal level of pollution is generally not equal to zero.
4. Why are market-based instruments generally more efficient policies for dealing with externalities than are regulations?
5. Should governments tax the use of four-wheel-drive cars in urban areas? If so, why and how?
6. Why is a tax on an externality at the existing marginal damage cost likely to be inefficient?
7. The marginal cost of a plant producing chemical materials is represented by the equation $MC = 100 + 25Q$. However, including the costs of wastes, the marginal social cost is $MSC = 100 + 50Q$, where Q is units of output. Assume that in the competitive market the chemical product can be sold for \$250. How much will the firm produce? What is the socially efficient level of output?
8. Suppose that a firm operating in a competitive market produces a negative externality by way of toxic emissions.

   The marginal cost of production is represented by $MC = 5Q$. Also each unit of output produces an externality equal to $2Q$. The firm faces the demand curve of $Q^d = 420 - P$. Determine the following:

   i. The equilibrium level of output and equilibrium price, where the firm ignores the effects of the externality.

   ii. The tax to be levied if government chooses to impose a per unit tax on each unit of output of the firm to account for the pollution costs involved in production.
9. Two firms are located next to a river: an upstream chemical firm and a downstream hotel. The chemical firm obtains water from the river and disposes of waste into it. The hotel gains from the amenity of the river. The net income of the chemical firm is $Y_F = 32 + 12C - 0.25C^2$, where C is the amount of pollution pumped into the river. The net income of the hotel is $Y_H = 200 - 8C$.

   i. Derive the schedules for the marginal benefit of pollution to the chemical firm and the marginal cost to the hotel. What is the efficient level of pollution?

ii. If the hotel owns the property rights to the river and no bargaining takes place, how much pollution occurs?

iii. If the two parties bargain, does the chemical firm have any incentive to make an income transfer to the hotel?

If so, what is the minimum it would need to offer? Will it enjoy any surplus after this transfer?

iv. Now suppose that the chemical firm could acquire a technology to prevent any pollution and would obtain any surplus from any bargain with the hotel to reduce pollution. How much would the chemical firm be willing to pay for the technology?

10. The aggregate daily demand function for visits to an aquarium is $P = 100 - Q/10$.

i. What would be the total number of visits per day with free admission?

ii. If the marginal cost (MC) for serving each visitor is $15, how much should the aquarium charge and what would be the number of visits?

iii. Suppose that when visits per day exceed 500, the aquarium gets crowded, visitors block the views of each other and maintenance cost rises. The MC rises by $0.10 per additional visitor over 500. For example, for the 510th visitor, MC = $15 + (10× $0.10) = $16. In this case, what is the equilibrium number of visits and how much should the aquarium charge?

11. Why, for any given target reduction in CO_2 emissions, is government direct action to invest in green technology likely to cost the average Australian household more than a carbon tax?

12. What is the difference between a common property resource and a public good?

13. Does the method of allocating permits to use a common property resource, such as a fishery, affect the economic outcome?

Further Reading

Bovenberg, A.L. and Goulder, L.H. (2002) 'Environmental Taxation and Regulation', pp. 1474–1545 in A.J. Auerbach and M. Feldstein (eds) *Handbook of Public Economics*, Vol. 3, Elsevier Science, Amsterdam.

Clarke, H. (2011) 'Some basic economics of carbon taxes', *Australian Economic Review*, 44, 123–136.

Coase, R. (1960) 'The problem of social cost', *Journal of Law and Economics*, 3, 1–44.

Gruber, J. (2016) *Public Finance and Public Policy*, 5th ed. Chapters 5 and 6, Worth Publishers, New York.

McWhinnie, S.F. (2009) 'The tragedy of the commons in international fisheries: An empirical examination', *Journal of Environmental Economics and Management*, 57, 321–333.

Ostrom, E. (2000), 'Collective action and the evolution of social norms', *Journal of Economic Perspectives*, 14, Summer, 137–158.

Rosen, H and Gayer, T. (2014) *Public Finance*, 10th ed., Chapter 5, McGraw-Hill, New York.

Tietenberg, T. (2006) *Environmental and Natural Resource Economics*, 6th ed., Chapter 4, Addison Wesley, New York.