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The State of the Environment and the Availability of Natural Resources

by

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The State of the Environment and the Availability of Natural Resources

Abstract

This is a draft chapter for K. Hartley and C. Tisdell, *Microeconomic Policy*, Second Edition. It is designed to illustrate how microeconomics can be applied to the analysis of issues involving the environment and the availability of natural resources and policies to address these issues. It outlines the micro-basis of a number of macro-environmental relationships, considers environmental externalities and their regulation, analyses some environmental relationships involving public goods or public bads, introduces the concept of total economic value and discusses the consequences of open-access and common property resources and policies to control their use.

The State of the Environment and the Availability of Natural Resources

1. Introduction

Because of long-term economic growth, the volume of global production is now very large. Economic growth has altered natural environments and continues to do so, and it also impacts on the availability of natural resources. Consequently, the state of the natural environment is not independent of economic activity, and vice versa. Economic growth has resulted in concerns about the continuing availability of clean air and water, the disappearance of natural and semi-natural landscapes, loss of biodiversity, and increasing greenhouse gas emissions (for example, from the combustion of fossil fuels); sparking fears of considerable climate change and sea-level rises (Stern, 2006; BBC, 2006; Anon, 2006). In addition, there are periodic concerns that important natural resources, such as oil reserves and natural fish stocks, are being depleted and that this will result in shortages which will eventually reduce standards of living.

Microeconomic analysis can help us assess such issues. Furthermore, if there are socially unwanted environmental changes, including unwanted natural resource depletion, as a result of economic activity, often appropriate microeconomic policies can be adopted to alleviate such problems. This is not, however, to suggest that microeconomics on its own and microeconomic solutions can solve all environmental problems. Generally, the study of environmental problems calls for an interdisciplinary approach. Furthermore, the adoption of particular public policies have social impacts and almost always have ethical or normative objectives. Individuals may disagree about the appropriateness of such objectives. Should human wishes be paramount in deciding on policies, or should the preferences of humans be taken into account subject to ethical constraints, such as the possible right of other species to exist or to be free from undue molestation by humans? Do animals or other species have rights independently of human wishes? Different ethical perspectives often result in disagreements about choice of economic policies.

Mainstream economics is based on the view that only human welfare counts. It is, therefore anthropocentric. However, it does allow the (perceived) welfare of non-human entities to be taken into account if this affects the utility of humans. For example, if some individuals are distressed by the harvesting of whales, then their willingness to pay to prevent whale harvesting would be taken into account in trying to determine an optimal economic solution to the harvesting of whales (Tisdell, 2005, p.115). Therefore, even the relatively anthropocentric approach of economics to policy displays some sensitivity to changing human values about non-human species.

Because the available literature on environmental and natural resource economics is now very extensive, this chapter should be regarded as only an introduction to the subject. It is developed by first briefly considering aggregate relationships between economic growth, the state of the environment and the availability of natural resources because much of the theory involved is based on microeconomics. Then important economic concepts for environmental analysis and policy such as environmental externalities or spillovers, public goods and bads are introduced. Microeconomic policies designed to remedy environmental problems arising from the presence of externalities, of public goods or bads and inadequate systems of property rights are also outlined and examined.

2. Economic Growth, the Environment and Natural Resource Availability: Macro-perspectives

Concerns have emerged in the last few decades that continuing economic growth of the type experienced in the past may prove to be unsustainable because of environmental pollution associated with it and the depletion of non-renewable natural resources, such as fossil fuels. For example, because of their rapid economic growth, China and India have become major users of natural resources and emitters of greenhouse gases. However, many higher income countries, particularly the USA, although showing less current economic growth continue to be major users of natural resources and emitters of greenhouse gases. Much of the discussion is based on the use of microeconomic concepts. The purpose of this section is to illustrate this and provide a broad backdrop to environmental issues.

It is now widely recognised that natural resource stocks are economic assets. They contribute to human productivity and often directly to human welfare in a similar way to man-made capital and assets. They are essential to human survival and they play an important role in sustaining economic productivity and human welfare. The following question has arisen: Given that natural capital or assets complement the productivity of man-made capital and contribute to the bundle of commodities that individuals want to consume, such as clean air or natural landscapes, to what extent can the natural resource stock be degraded or depleted and economic productivity and welfare be sustained?

To some extent, the answer to this question depends on how easily, and to what extent, man-made commodities can be substituted for natural commodities. For illustrative purposes, the set of available commodity possibilities could be represented by a product or commodity transformation function. Most, if not all, man-made commodities rely, either directly or indirectly, on the use of some natural resources.

Given available technology and knowledge of the availability of natural resources, the economy's product or commodity possibility function might be represented by curve ABCD in Figure 16.1. The economy can be envisaged as a global one or a more localised one. This indicates that if production of man-made commodities is on a relatively low scale, say less than Y_1 per period, little availability of natural commodities has to be foregone but as production of man-made commodities per period rises above Y_1, greater availability of natural resources has to be foregone for each unit increase in production of man-made commodities. This means that the marginal opportunity cost of producing man-made commodities rises in terms of natural commodities foregone, as man-made production increases. If attempts are made to increase man-made production to very high levels, the availability of natural commodities may be reduced to such an extent that the level of man-made production cannot be sustained. For example, attempts to increase the level of man-made production beyond Y_3 may prove to be counterproductive. It could result in both man-made production falling as well as the availability of natural commodities that is, a movement along the segment AB of the commodity-possibility curve in Figure 16.1.

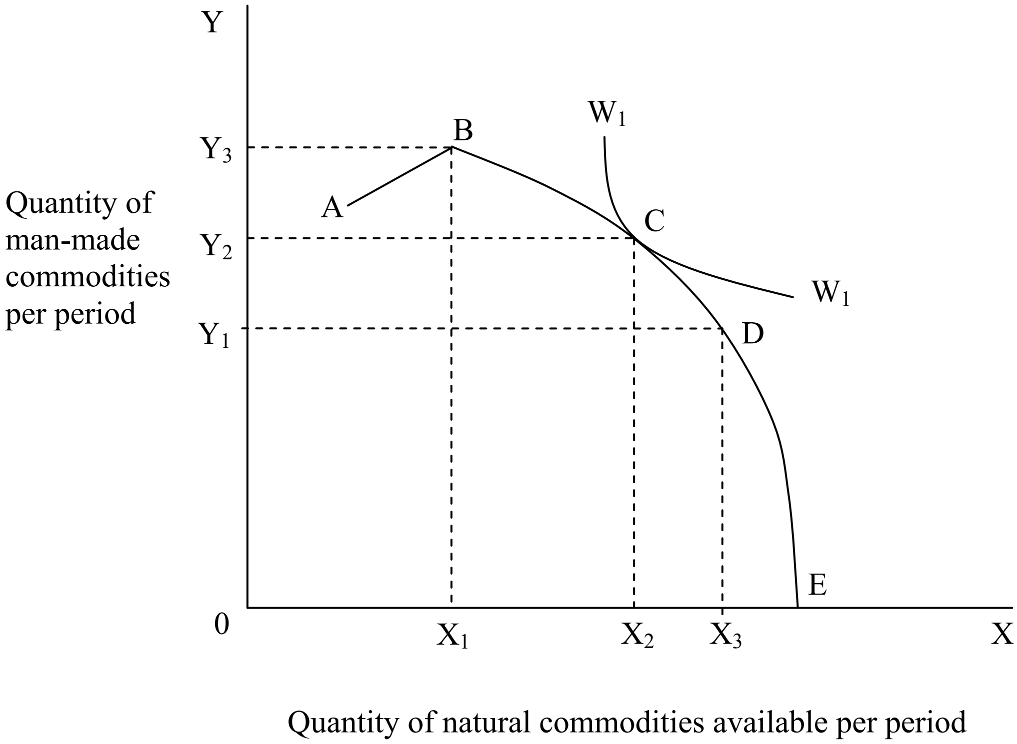


Figure 16.1 Man-made production relies to a large extent on the use of natural resources. This can result in increasing natural resource scarcity with economic growth and socially excessive use of natural resources. Technological change and the discovery of new natural resources stave off this problem.

In Figure 16.1, point B corresponds to the maximum level of available man-made commodities. However, this is not necessarily the ideal combination from a social point of view because many natural resources are themselves valued by individuals, for example, beaches and natural scenery. Consequently, the socially ideal combination of commodities is likely to be to the right of B, for example at point C, assuming that the social welfare indifference curve marked W_1W_1 is the highest attainable one. Because of market failures, there is a risk that an economy can move to a point left of C, such as B or even A.

If the economy is at a point on the transformation function well to the right of C, there should be little or no concern about reducing the amount of natural commodities in order to produce more man-made commodities. As C is approached, more concern is needed because the risk increases of the economic system moving to the left of C. Therefore, weak restrictions might be placed on economic growth when the economy is well to the right of C and natural resources are abundant. However, stronger restrictions on economic growth (which transforms natural resources) become appropriate as the availability of natural resources dwindles.

Nevertheless, with the passing of time, two factors can reduce the natural resource constraints to the production of man-made goods. Technological progress could reduce the amount of natural resources needed to produce man-made goods. This would cause the transformation function to move to the right with the point E, the known availability of natural commodities remaining fixed. In other words, the function would rotate clockwise on the fixed joint, E. Secondly, new natural resources may be discovered. This effectively moves point E to the right. Both technological progress and the discovery of new natural resource stocks stave off the problem of natural resource scarcity. Nevertheless, opinions differ about how effective they are likely to be in the long term in overcoming economic problems associated with natural resource depletion and environmental degradation associated with increasing production of man-made commodities.

It can be seen that production function concepts developed in microeconomics underlie the above simplified exposition of the problem of natural resource scarcity and this illustration of environmental constraints to sustaining growth of economic production. Consider another application of microeconomic concepts.

The environmental Kuznets curve (EKC) relates the intensity of the emission of pollutants to the level of Gross Domestic Product (GDP) of a nation. The intensity of the pollution is measured by the amount of a pollutant emitted per unit of GDP and is therefore, an average concept. It is believed that typically environmental Kuznets curves are of a reversed U-shape, as indicated in Figure 16.2 by curve 0BC. This curve has similarities to per-unit production functions in microeconomics. The EKC has associated with it a marginal curve indicated in Figure 16.2 by curve DBF. This is above EKC, when EKC is rising, and below EKC when EKC is falling.

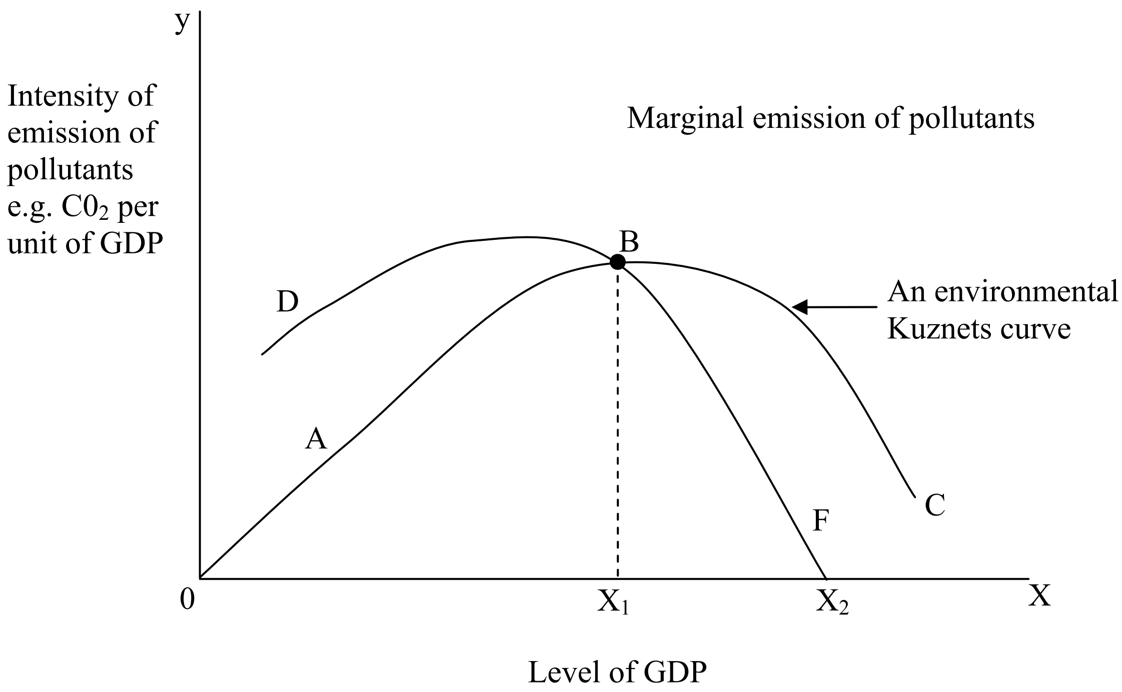


Figure 16.2 Environmental Kuznets curves are believed to be typically of a reversed U-shape. With sufficient economic growth, it is therefore, possible that pollution levels could fall. There is, however, a risk of being too optimistic in this regard, as explained in the text

The EKC implies that as economic growth occurs, pollution intensities rise at first, and with sufficient economic growth will eventually decline. However, it should be observed that the maximum intensity of pollution emission (which occurs at B for a level of GDP of X_1 in Figure 16.2) does not indicate the maximum amount of pollution emission per unit of time. This corresponds to the level at which marginal emissions equal zero, a level of GDP equal to X_2 in Figure 16.2. This could be well in excess of the level for which pollution intensity reaches its maximum.

Secondly, it should be observed that the EKC relates to the flow of pollutants not their stock. The natural environment may not be able to neutralise or absorb all pollutants, especially as their volume of emission rises. Therefore, the stock of pollutants may accumulate, such as has happened with $C0_2$ emissions. It is possible that even if current emissions begin to fall that stocks of pollutants in the environment can continue to rise. In Figure 16.2, even if marginal emission of the relevant pollutant becomes negative (GDP > X_2), its total emission may still be so large that the stock of the pollutant in the environment continue to rise. A very large reduction in emissions may be needed before the level of emissions of some pollutants can be absorbed by natural processes and can no longer add to stocks of pollutants.

Furthermore, emissions of all pollutants may not have the reversed U-shape of the EKC, and pollution emissions or levels of accumulation beyond some thresholds may trigger massive environmental changes (Tisdell, 2001). The latter is not accounted for by environmental Kuznets curves. However, it is a concern in relation to emissions of greenhouse gases. The accumulation of these is predicted to bring about significant global warming and climate change as well as a rise in sea levels.

3. Environmental Externalities, Spillovers, and Relevant Microeconomic Policies.

Externalities or spillovers have been discussed in Chapters 2 and 6. It was pointed out that an externality or a spillover exists when economic activity engaged in by one party harms or benefits another, and no payment is made by the originator of the activity to compensate the damaged party or no payment is made by the beneficiary for the benefit recorded. This can result in market failure because some of the costs or benefits associated with economic activity are not priced. The originator of an activity causing an adverse externality does not pay the full marginal (social) cost associated with the activity. Similarly, the originator of a favourable economic spillover does not obtain the full marginal (social) benefit from this activity. Therefore, an activity generating unfavourable externalities is liable to be overextended from a social point of view and an activity having favourable spillovers is likely to be on a smaller scale than is socially optimal.

Many types of economic externalities or spillovers are associated with shared environments. Such environmental spillovers can include water, air and soil pollution of various forms, changes in hydrology (water systems) and alterations in local, regional, or global climate. Variations in scenery, impediments to views and to light or air movements caused by buildings may have external effects; loss of shared species such as liked species of wildlife or ecosystems (reduced biodiversity) can have adverse external effects. On the other hand, reduced population of species, such as mosquitoes and rats, which create health hazards may be viewed as having a positive externality. Activities generating radiation can potentially or actually give rise to negative spillovers. The ‘melt-down’ of the Chernobyl nuclear power plant for example led to severe adverse externalities and even now the site continues to pose some environmental risks. The range of possible environmental spillovers is very large. The above just gives an indication of the range.

Arthur Pigon (1932) was the first economist to consider market failures that may arise from economic externalities. He proposed taxing the production of industries that gave rise to adverse externalities and subsidising those generating favourable externalities. His approach can be illustrated by the example given in Figure 16.3. While this example relates hypothetically to the steel industry , it can be adopted to apply to other industries which generate negative environmental spillover. The air transport industry, for example, has negative environmental externalities as a result of its noise and carbon dioxide emissions.

In Figure 16.3, the line marked DD represents the market demand for steel, and the line marked SS is the supply curve of steel. The latter represents the marginal private cost of producing steel. The steel industry is assumed for illustrative purposes to be a perfectly competitive industry. Consequently, market equilibrium is established at point E. However, steel production may cause unfavourable environmental spillovers as a result of emissions of particulate matter (smoke), carbon dioxide, sulphur dioxide and other gases. Particulate matter may, for example, increase the incidence of lung diseases and emissions of sulphur-dioxide may contribute to the occurrence of acid rain. When this is taken into account, the social marginal cost of steel production may be as indicated by the line ABC. The difference between line SS and line ABC, FB, represent marginal environmental spillover costs from steel production.

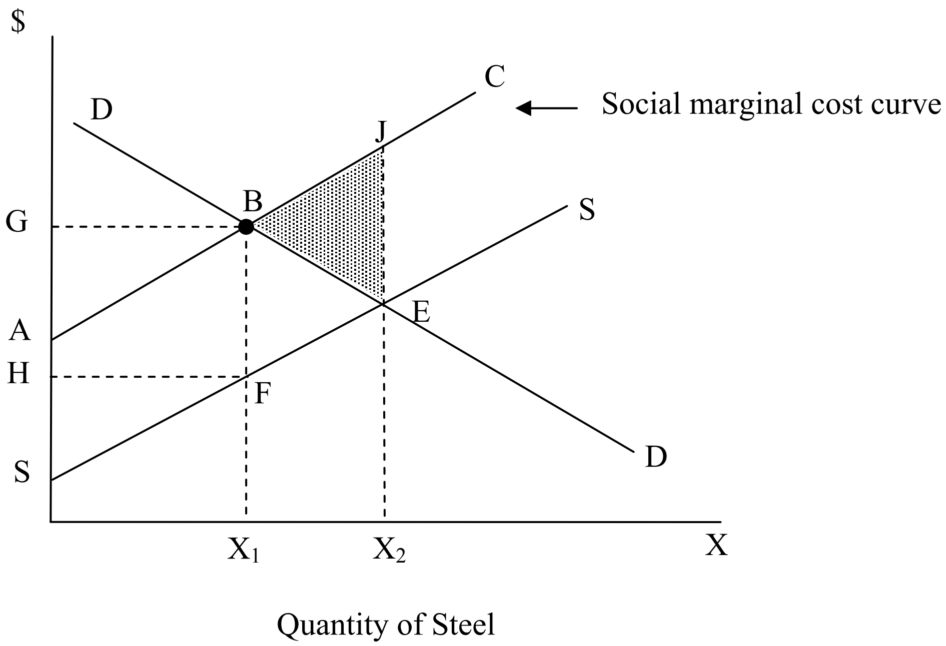


Figure 16.3 An illustration of Pigou's approach to the regulation of environmental spillovers

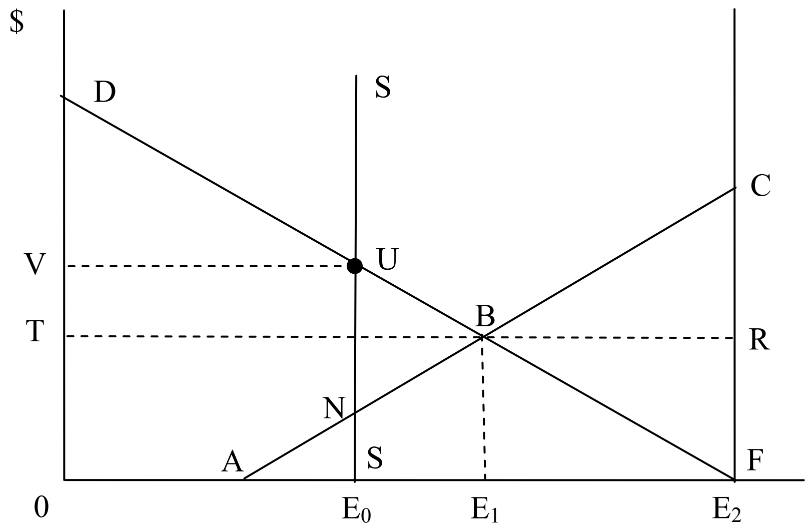
These externalities will not be taken into account by steel producers. Hence, they produce X_2 units of steel and the social marginal cost of this production corresponding to point J exceeds its private marginal value, corresponding to point E on the demand curve. A social deadweight loss equivalent to the area of triangle BEJ occurs. Pigou (1932) suggested that this might be remedied by placing a tax of BF on each unit of steel production. As a result, after payment of this tax, the private marginal costs of steel production would be aligned with the social marginal cost of steel production and the industry would come into equilibrium at point B, with its level of production being reduced from X_2 to X_1. At point B, the social marginal cost of steel production equals the extra value placed on it by buyers. There is no social economic loss, so it seems. However, this assumes that the technology and input requirements for steel production are fixed. If this is not so, it may be more efficient to place a tax (or taxes) directly on unfavourable emissions of pollutants, or charge polluters for these by other policy mechanisms, such as by using a system of tradeable pollution rights, discussed below.

To make the polluter pay directly for offending pollution emissions can be more efficient for several reasons. First, it provides an incentive for the polluter to use inputs that are less polluting if there is a choice. For example, in the above case, low sulphur coal may be substituted for high sulphur coal if there is a charge on sulphur dioxide emissions. This will not happen if steel production is taxed. Secondly, it may encourage the installation of technology that reduces pollution emission. For example, if there is a charge for emission of a particulate matter, scrubbers may be installed on smoke stacks which reduce such emissions. Thirdly, this policy provides an economic incentive for inventions, innovations and adoption of technologies that will reduce relevant emissions. It provides pollution reduction with private economic value. The Pigovian tax on products does not have these effects.

On the other hand, the monitoring and enforcement costs of charging fees on actual emissions can be high. These costs are likely to be lowest where emissions can be measured at a single point or a few points. However, this system of regulation can become impractical when there are non-point emissions. For example, the nitrogen and phosphorous run-off from fertiliser and animal manure on farms has negative environmental spillover consequences but can be very difficult to measure. Therefore, "second-best" policy solutions may have to be adopted, such as limiting fertiliser use or the type of agriculture permitted, or stocking rates of farm animals. Run-off of nitrates and phosphorous causes nutrient-enrichment of water which often promotes excessive weed and algal growth. This may choke water bodies making these unfit for many conventional uses, such as swimming, fishing and boating. Fish stocks may be reduced or altered in favour of less paletable species. Water quality is likely to deteriorate and it may become unsuitable for drinking by humans and livestock.

The analysis introduced by means of Figure 16.3 can be extended to consider several alternative microeconomic policy options that can be used to regulate pollution emissions. Systems of pollution taxes, levies or fees and of tradeable pollution permits use pricing systems to bring about desired levels of pollution emission. In principle, they can lead to the same level of pollution control but there are practical differences.

The similarities between pollution taxes or fees and systems of tradeable permits can be visualized by mean of Figure 16.4. There, line DBF represents the marginal benefit to polluters of being able to pollute and line ABC represents the marginal cost to victims of the pollution and is a spillover cost. No external costs are imposed until pollution emissions exceed the threshold 0A. OABC may, for example, be the estimated marginal cost of increased morbidity and mortality as a result of the pollutant emitted. In the absence of any restrictions on pollution spillovers, polluters will maximize their economic benefit by emitting E_2 of the pollutant and a social deadweight loss equal to the area of triangle BFC will occur. The most economic level of emissions, applying the Kaldor-Hicks criterion, is E_1. This can, in principle, be achieved by means of a number of alternative economic policies.



Quantity of pollutant, E_2 emitted per unit of time

Figure 16.4 Illustration of alternative microeconomic policies for controlling pollution emissions

One possible policy measure is to impose a tax or charge of OT on pollution for each unit of the pollutant emitted. This reduces the private benefit obtained from polluting. For levels of pollution emissions beyond E_1, the marginal benefit to polluters, shown by BF in Figure 16.4, is less than the marginal tax (or marginal charges imposed) as shown by BR. Therefore, polluters maximise their profits by reducing their pollution emissions from E_2 to E_1.

Alternatively, pollution permits or certificates giving rights to the holders to emit pollutants may be issued. Often these are issued in proportion to the past level of emissions of each existing polluter. This allocation is often free of charge, a practice sometimes called 'grand fathering'. The property-rights bestowed on existing polluters provides them with a marketable asset and helps purchase their political support for regulation of pollution. To achieve the optimal economic result, enough permits should be issued to allow an aggregate level of emissions of E_1. If these pollution rights are marketable and if perfect competition exists, a vertical line located on E_1 represents their supply, and line DBC indicates the demand for the permits. Hence, the market for rights comes into equilibrium at B and the market price of each permit is OT. Thus, the same level of emission emerges as in the case where a tax or levy of OT is imposed on each unit of pollutant emitted.

In practice however, the marginal cost and benefit curves shown in Figure 16.4 may not be known or may be poorly known, and/or be subject to controversy. Or again special interest groups may exert political pressures and an ‘optimal’ economic solution may not be adopted by the government. It may adopt a standard that differs from the economic ideal. For example, in the case illustrated in Figure 16.4, the government may opt for a standard that only allows E_0 of pollutants per unit of time to be emitted. It may achieve this goal efficiently by either imposing a tax or fee of OV on each unit of the pollutant emitted or by issuing tradeable pollution permits allowing a volume of emissions equal to E_0. In the latter case, the supply of permits corresponds to the vertical line marked SS, and the demand curve for those rights is shown by line DF. Assuming perfect competition, market equilibrium is established at U and the price of each permit is OV. In this simplified theoretical case, both policies result in the same level of emissions of the pollutant.

Note, that although the standards approach is not ideal from a social economic point of view, it can be socially better than no intervention at all. For example, in the case just discussed, the social deadweight loss when a pollution standard adopted is equal to the area of triangle NBU. This is less than the area of triangle BFC which represents the social deadweight loss from pollution in the absence of government intervention.

There has been considerable discussion of whether taxing pollution is a superior approach to a system at tradeable pollution rights. In a dynamic situation both involve challenges because the marginal curves shown in Figure 16.4 may shift with the passage of time. For example, the marginal costs for the victims of pollution may shift upward. This may occur because the level of population in the polluted area increases, for instance. Other things equal, this would call for a reduction in emissions. This might be achieved by either raising the pollution tax or fee or reducing the number of pollution permits.

However, depending on the political processes involved, changing the level of the pollution tax may be slow and difficult. Furthermore, if permits have been issued, they are a type of property right. Whether and how the entitlements to emit pollution can be reduced depends upon the conditions of their issue. If the pollution permits are rights in perpetuity, then the government may have to purchase some to reduce their number. This can be costly. If on the other hand, the rights only give permit-holders a proportionate slice of the total allowed level of emissions, this provides the government with more flexibility to alter the aggregate level of emissions.

An important policy consideration is how to provide holders of pollution permits with some security of property rights and yet allow some flexibility for the government to adjust to changes in the public interest without its incurring large financial outlays. A variety of pollution permit schemes can achieve this. For example, apart from schemes giving permit-holders rights to a fixed share of the total allowable level of emission of a pollutant, schemes are possible in which a proportion of permits revert to the government with the passage of time. The government could then decide to freeze these; or reissue all or part of these, or even issue extra permits, depending on the circumstances. In doing this it needs to balance the security of property rights of permit holders against changes in the public interest. Some of the issues involved are discussed, for example, by Tisdell (2003, Chs. 17 and 18).

The Stern Report to the UK Government (Stern 2006) concluded on economic grounds and on the basis of evidence from natural science, that urgent global policy action is required to reduce the rate of growth in global greenhouse gas emissions, stabilise the level of such emissions, and then reduce it. Stern found that the economic benefit of taking action now, or in the near future, will exceed the cost of doing so. The economic benefit of speedy action is estimated as the economic costs (economic losses) averted which would occur with global warming and associated environmental change if business continues as 'usual'. One of the report's recommendations is that the European Union's Emission Trading Scheme be extended globally to include such countries as the United States, China and India. This scheme is intended to stabilise the total levels of carbon emissions but its total allowable level of emissions would need to be reduced in the future. A stumbling block could be disputes about the relative allocation of initial permitted levels of emissions to countries not already in the EU scheme; that is the initial distribution of rights to emit greenhouse gases. China and India might argue or believe that it is equitable for them to have the lion's share of rights, because the countries that have already developed have been the major contributors to rising levels of greenhouse gases and have a smaller population.

A different property rights approach to regulating environmental externalities has been suggested by Coase (1960). He is of the view that many economic failures attributed to environmental externalities occur because property rights are uncertain or not defined. He believes that many economic failures due to externalities would disappear if property rights were more precisely defined and to be legally enforceable. He predicts that in ideal circumstances, this would promote bargaining between those responsible for an externality and those subject to it and result in a Paretian optimal outcome being negotiated by the parties, that is an agreement in which no party to the negotiations can be made better off without making another worse off. Furthermore, Coase claims that the negotiated solution conditions will be the same (in terms of the amount of pollution emitted) whether the rights are given to the polluter or the victims of the pollution. This has been dubbed the Coase Theorem. However, the income distribution consequences are very different depending on whether rights are assigned to polluters or their victims. If polluters have the right to pollute, then real income will be redistributed in favour of polluters given Coase's approach. On the other hand, if the victims of the pollution have the right to a pollution-free environment real income will be redistributed in their favour if Coase's negotiated solution applies. This is illustrated by Figure 16.5, which is the same as Figure 16.4 with a minor modification to improve exposition. OBC in Figure 16.5 now represents the marginal spillover costs of pollution to victims and as before, DBF is the marginal benefit to polluters of being able to pollute.

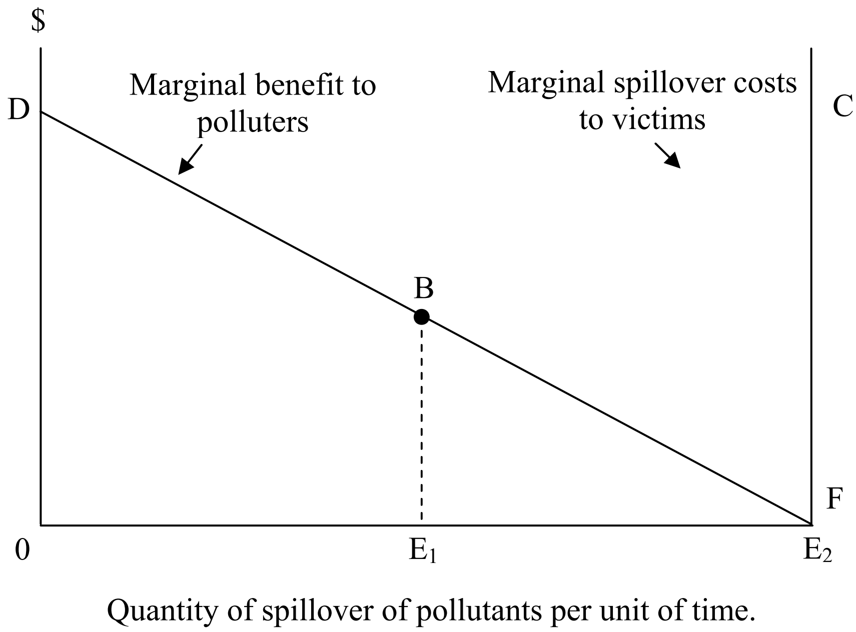


Figure 16.5 An illustration of Coase's Theorem

Now if ideal conditions exist and property rights are clearly defined, the Coase Theorem implies that negotiations will result in an outcome corresponding to point B in Figure 16.5 and a level of emissions equal to E_1. If polluters have the right to pollute, they could, in the absence of bargaining, emit E_2 of the pollutant. However, they would be willing to accept a payment equal to the area of triangle E_1BF to reduce this level of pollution emissions to E_1. In principle, victims could be willing to pay this amount and with this payment would be better off as a result of the reduced level of emissions by an amount equivalent to the area of triangle BFC. Income will be transferred in favour of polluters. However, a bilateral bargaining situation may emerge. Polluters may demand a transfer of more than the area of triangle BE_1F because the maximum victims could be willing to pay for a reduction in pollution emissions is an amount equal to the area of quadrilateral BE_1FC. Thus, the negotiated income transfer could be at or between those extremes.

Similarly, if those subject to pollution have the right to a pollution-free environment, they can make an economic gain by permitting some pollution in exchange for compensation by polluters. The maximum marginal amounts that polluters are willing to pay are shown by line DBF and the minimum marginal compensation that victims are willing to accept is shown by line 0BC. In Coase's ideal world, bargaining by the parties would result in emissions at E_1.

Polluters would transfer income to victims and the amount transferred would be at a minimum equal to the area of triangle $0E_1B$ and at a maximum equal to the area of quadrilateral $0E_1BD$.

While clearly defined property rights to either polluters or victims results in this idealised world in a Paretian efficient outcome, the income distribution consequences are very different. Ethical or moral issues would need to be taken into account in deciding which parties should be given the property rights. It is also possible that bargaining uncertainties and frictions could prevent a negotiated solution being achieved.

In practice, the ideal conditions required for Coase's solution are rarely satisfied. It assumes that bargaining costs are absent, and that the legal enforcement of property rights is costless and certain. In addition, any bargained outcome negotiated is supposed to be binding. In practice, those conditions are rarely satisfied. If they were, externalities would be rare.

Also barriers to bargaining often differ between the parties. For example, if there are many victims and each is damaged by a small amount by the emission of a pollutant, no one may wish to bargain because the cost to initiators of the bargaining process may exceed their potential benefits. While class legal actions in some countries can be initiated by lawyers to help circumvent this problem, Coase's property rights solution is much less effective than the exposition of the idealised case suggests. That is not to suggest that a clear definition of environmental rights is unimportant. However, often government (public) action is required to ensure that these rights are respected. Private negotiations do not always result in an ideal economic outcome, even when property rights in the environment are clearly defined. Nevertheless, private negotiations do sometimes work. For example, recreational anglers in the United Kingdom who value river fishing for salmon have, in some areas, bought out net fishermen based in estuaries so as to increase their availability of salmon stocks for recreational fishing.

Zoning and separation of activities provides another means of dealing with externalities. For example, smoking areas may be separated from non-smoking areas, industrial areas may be separated from residential areas and so on. This can be an economical policy measure when externalities have localized effects.

In discussing pollution taxes and tradeable pollution permits, it was assumed that the marginal externalities generated were independent of the geographical location of the activities involved. However, this is not always so. This can require pollution taxes or fees to be varied according to geographical location of a pollution emission in order to take into account differences in the marginal benefits and marginal spillover costs to each locality (Tisdell, 1999, Ch.4). If a system of tradeable permits is used, the supply of permits needs to be specific to each region. This can make the market for permits 'thin' in some regions because there may be few firms with permits in some areas and the market for pollution permits may become imperfect.

It should also be noted that it is by no means easy to measure accurately the cost and benefits associated with environmental externalities. Nevertheless, several alternative methods are available. While these may provide differing estimates, this in itself should not be an excuse for policy inaction. For example, take the case shown in Figure 16.6. There ABC is the marginal economic benefit to polluters of emitting a pollutant. DBF represents the marginal damage to victims according to one estimate and D′B′F′ according to another estimate. If these are the range of estimates, it will be socially preferable to reduce emissions from E_2 to E_1 rather than do nothing in each case.

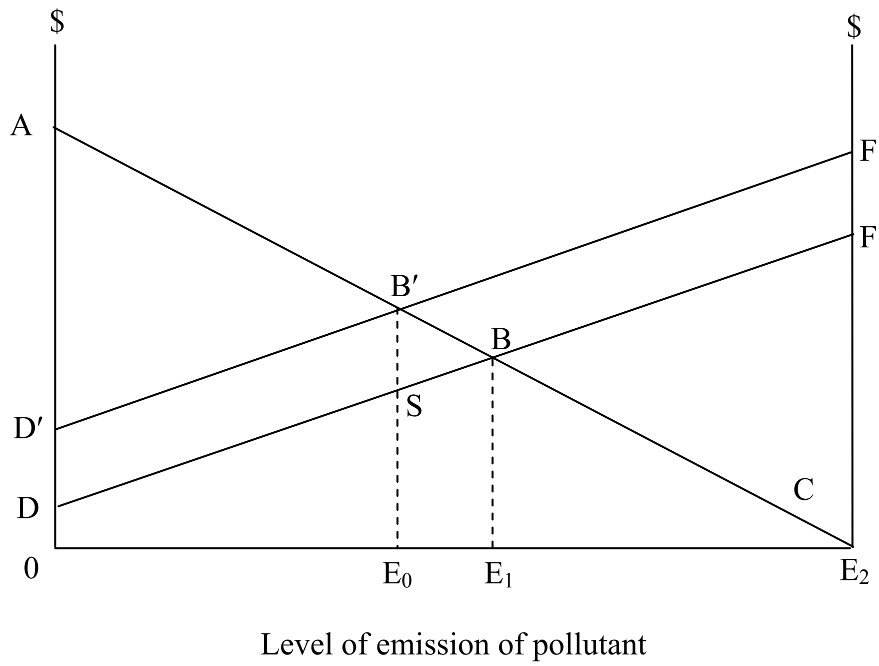


Figure 16.6 Uncertainty about the costs and benefits of pollution control can rarely be used as a reason for policy inaction

A reduction in emissions from E_1 to E_2 will ensure an aggregate economic gain equivalent to, at least, the area of triangle BFC. In this case, even a reduction in emissions to E_0 is bound to yield an aggregate economic gain. It ensures a gain equal to, at least, the area of triangle BFC less the area of triangle BSB′, and the latter triangle is smaller in area than the former.

Line DBF might represent the marginal costs of ill-health caused by a pollutant and may consist of victims' medical and hospital expenses and their loss of earnings due to ill-health. Line D′B′F′ might provide an additional allowance for their pain and suffering and earlier mortality than usual. Even if this additional consideration is ignored, it will be socially beneficial to reduce pollution emissions to at least E_1.

In some cases, the willingness to pay for the avoidance of an unfavourable externality by those subject to it is used as an estimate of spillover costs and in other cases, willingness to accept compensation to allow the spillover is the basis of the estimates. Estimates based on the latter approach (Knetsch, 1990; Perman et al., 2003, Ch 12) have been found empirically to exceed significantly those based on the former approach. However, in line with the above argument, this difference should not rule out all public intervention to regulate environmental externalities. For example, if in Figure 16.6, $D'B'F'$ represents the marginal willingness to accept compensation to allow pollution, and if DBF represents the marginal willingness to pay to avoid pollution, a reduction in the level of pollution from E_2 to any level in the region $E_0 \leq E \leq E_1$ will be socially preferable to no reduction in the level of pollution, if the Kaldor-Hicks criterion is applied. The Kaldor-Hicks criterion regards an economic change to be a social improvement if those gaining from it could at least compensate those losing from it and be better off than before the change. Thus, no matter whether DBF or $D'B'F'$ is considered to be the appropriate measure of marginal externality cost of the emission of the pollutant, it is socially more economical to ensure that pollution emission is in the above mentioned range than not to regulate it at all.

This result does, however, undermine the 'neatness' of Coase's theorem. This is because if, for instance, victims have the right to a pollution-free environment the relevant marginal damages function from their point of view would be based on their willingness to accept compensation. On the other hand, if polluters have the right to pollute, it will be based on the willingness of victims of pollution to pay to avoid it. In the former case, a marginal damages function like DBF will apply and in the latter case, one like D′B′F′. Thus, the amount of pollution that will be Paretian optimal will depend on the allocation of property rights.

4. Environmental Effects as Public Goods or Bads

Public goods are goods that once supplied can be enjoyed by all (their consumption cannot be made dependent on a payment) and their consumption by one individual does not reduce their availability to others. These attributes have been described in the relevant literature as non-excludability and non-rivalry. Public bads involve environmental effects from which no one can be excluded and which are not reduced by any individual being affected by them.

Greenhouse gas emissions, emissions of substances that destroy the ozone layer, and loss of biodiversity are often viewed as public bads. The self-interest of nations may drive them to contribute to these bads and lead to a situation in which all or many nations are damaged. Global international agreements, such as the Kyoto Protocol, are intended to try to avoid mutually damaging environmental outcomes.

This matter can be illustrated by a simple game of strategy which shows that individuals or nations by following their own self-interest can damage their common good. For simplicity, assume two nations and that each has two strategies: reduce greenhouse gas emissions, and not to reduce greenhouse gas emissions. Let these strategies for nation I be represented by α_1 and α_2 respectively and for Nation II be represented by β_1 and β_2 respectively. The economic payoffs to the nations from these strategies depend on their joint strategies. The numbers in the matrix in Table 16.1 displays the assumed payoffs. The first entry in each cell represents the payoff to Nation I and the second entry is the payoff to Nation II.

Table 16.1 An environmental example (greenhouse gas emissions) of how pursuit of individual self-interest may damage the common good.

		Strategies of Nation II →	
Strategies of Nation I		Restrict emissions	Do not restrict emissions
↓		β_1	β_2
Restrict emission	α_1	(10,10)	(3,15)
Do not restrict	α_2	(15,3)	(4,4)

It can be seen from Table 16.1 that no matter what the other nation does, it pays each nation not to restrict its emissions of greenhouse gases if it acts in its own self-interest. For example, if Nation II restricts its emissions, Nation I increases its gains from 10 to 15 by not restricting its emissions. If Nation II does not restrict its emissions, Nation I will gain 4 rather than 3 by doing likewise. Thus, there is a high probability that neither nation will restrict its emissions. Hence, each will be worse off than if they had all restricted their emissions. This problem (sometimes called the prisoners' dilemma problem) can only be overcome if both parties enter into an agreement to restrict their greenhouse gas emissions and act in good faith to carry out the agreement. Regulation of many global environmental problems requires international agreements of this type, that is international collective action.

In the absence of government intervention, public goods (which include reductions in public bads) are liable not to be supplied or to be under supplied compared to the demand for these. To take an example from environmental health, the control of mosquitoes carrying malaria is likely to be under supplied in economies where malaria is present if public measures to control these mosquitoes are absent. Owners of swampy land where such mosquitoes breed are likely to find that the cost to them of controlling the population of these mosquitoes on their land exceeds their benefits. But when the benefit of others in the region are also taken into account, the total economic benefit of this control may exceed the cost. Because a public good is involved (one for which a high external benefit exists), the government may have to supply the good to bring about a social optimum or at least, finance its supply.

Consider another example involving the conservation of a wild species, such as the northern hairy-nosed wombat in Australia. The remaining population of this species occurs only in a small area in Queensland where efforts are being made by government wildlife officers to increase its number. This area is not open to the public and the species is not allowed in zoos. The species appears to have no economic use value. Its total economic value consists of non-use value such as its existence value or its bequest value. Tisdell and Swarna Nantha (2007) discuss this case specifically. Many wildlife species have high non-use economic values but low or zero economic use values. Their populations are, therefore, pure public goods or nearly such goods. In the absence of government intervention, the conservation of their populations are likely to be less than socially optimal.

This can be illustrated by Figure 16.7. Assume, for simplicity, a society consisting of just two individuals and that each has the demand curve dA for conserving populations of the northern hairy-nosed wombat taking into account its public good characteristics, such as its existence and its bequest value. The aggregate demand curve for conserving population of this species is then as shown by line DA. For example, if each individual is willing to pay \$150 to conserve the first of the wombats, the aggregate value or demand for conserving these is \$300, and is equal to the distance OD in Figure 16.7. The line DA also represents this society's marginal valuation of additional wombats.

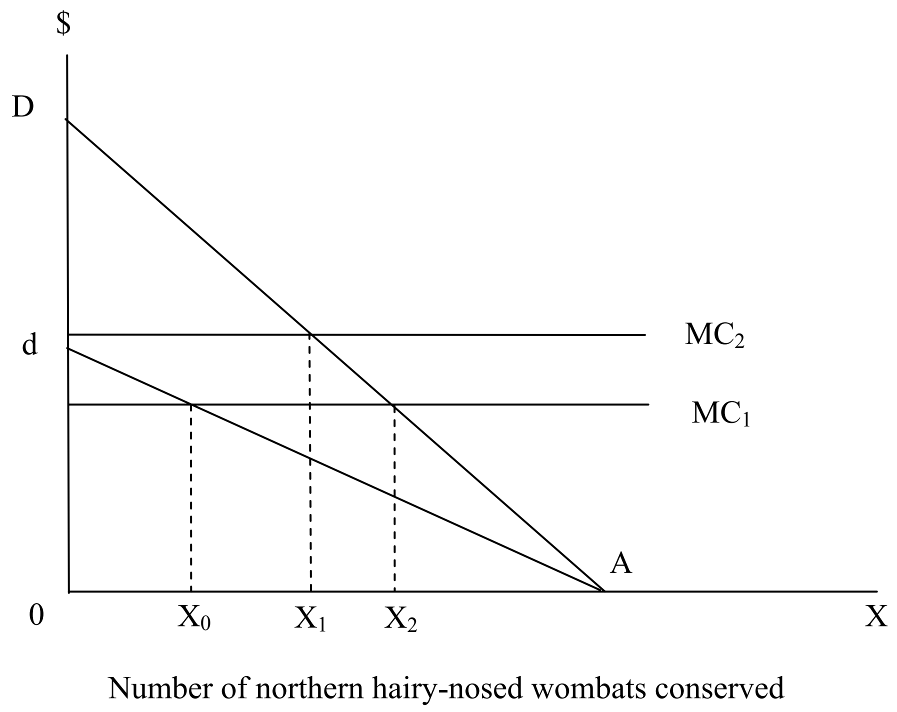


Figure 16.7 When an environmental commodity has public goods characteristics, it is likely to be under supplied.

If the marginal cost of conserving this species of wombat is as shown by the horizontal line marked MC_1, it is socially optimal to conserve X_2 wombats. For this population, society's marginal valuation of population of this species just equals the marginal cost of conserving them. In the absence of government intervention, one individual might conserve X_0 wombats and wombats will be insufficiently conserved. Should the marginal cost of conserving wombats be MC_2' no individual will conserve them, although the socially optimal number to be conserved is X_1. Thus, when environmental goods possess attributes of public goods, they are likely to be under supplied in the absence of public intervention. For example, there is likely to be insufficient conservation of wildlife species and ecosystems that have little use value but have high non-use economic values or public goods characteristics. This is so even though some individuals and voluntary organisations such as the Royal Society for the Protection of Bird Species, may help to conserve such species.

5. Total Economic Value, Mixed Goods and the Environment.

Some commodities are mixed goods in the sense that they have some attributes that give them economic use-value as well as other attributes that give them non-use economic value. Commodities with use-value are normally marketable whereas those with non-use value are not. Hence, the use component (private good component) of mixed goods may find a market whereas the non-use component (public good element) cannot be marketed. If a commodity or resource has attributes that provide it with both types of values, then in a market system, marketed use value is likely to dominate decisions about its conservation and use. The outcome may not be optimal from a social economic point of view.

According to one classification of economic values, the total economic value (TEV) of a commodity or resource is equal to its economic use value (TUV) plus its total non-use value (TNUV), that is TEV = TUV + TNUV.

Total use value can consist of consumptive value (for example, consumption of African elephants for their meat, leather and ivory) and non-consumptive value (such as the use of elephants for viewing by tourists). Non-use values reflect the fact that some individuals value the existence of resources independently of whether they intend to use them (for example, they may value the continuing existence of African elephants and be prepared to contribute to their conservation independently of any intention to use them) or they might wish to ensure that a resource continues to exist so that it is available to future generations (bequest value). Non-use values are usually important in relation to environmental goods.

The total non-use value of a resource or commodity can either be regarded as a public good attribute or an element generating an externality. If decisions about resource allocation are made purely on the basis of economic use value (as is normal in a free market system), misallocation of resources is liable to occur. This can be illustrated by some examples.

Consider a land area consisting of a natural forest that has no other economic alternative use but which can be logged for timber. The net economic value of its timber production represents a part of its economic use value. If the forested area is also used for outdoor recreation, this would be an additional use value. But, for simplicity, suppose its only economic use value is for logging. Its logging could threaten the population of a rare wild species and this threat might increase with the amount of land logged. Suppose that this species has no use value but that its existence is highly valued. As the extent of logging of the area increases, the marginal expected non-use value of the species will fall. This will not be taken into account by owners of the forested land. Because owners of the forested land do not appropriate any income from the non-use value of their forested land, an excessive amount of logging is likely to occur from a social economic point of view.

This is illustrated by Figure 16.8. There, line CAD represents the marginal economic return from logging different percentages of the forested area. Line OAB indicates the marginal reduction in expected non-use value that occurs as a result of the logging. From a Kaldor-Hicks economic point of view, the optimal degree of logging of the area corresponds to point A and involves x_1 of the area being logged. However, landholders will find it profitable to log all of the forested land because they obtain no economic returns from non-use values. This would result in a deadweight economic social loss equal the area of triangle ADB.

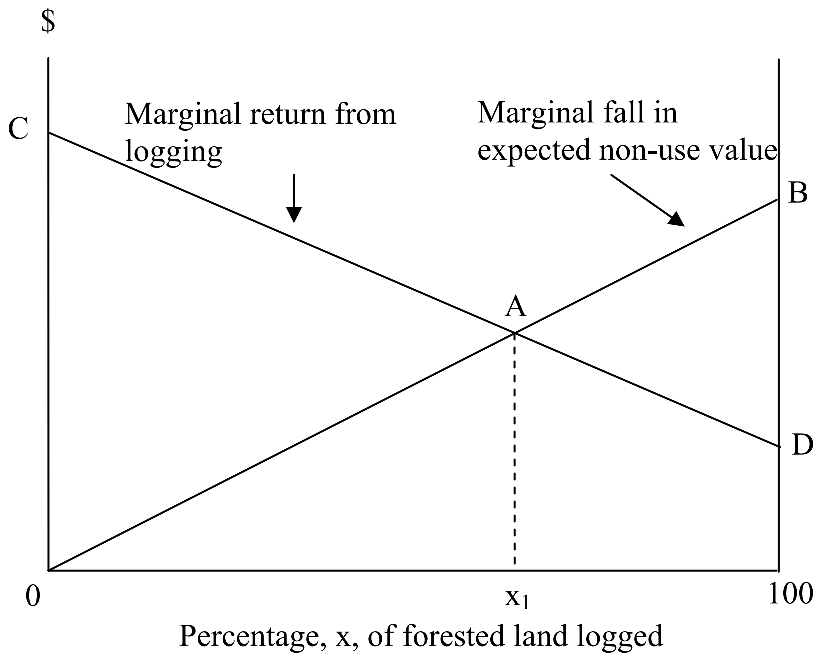


Figure 16.8 Illustration of how the presence of non-use value of resources can result in failure to maximise economic welfare.

Consider another mixed good case, namely whaling. Whales have consumptive use value for some Japanese and Norwegians, for example. They also have non-consumptive use value for whale watching, and they have non-use economic values for many conservationists. Whales are, therefore, a very complex mixed economic resource. There is economic conflict between those who wish to use whales for consumption and those who obtain greater economic value if they are not consumed. Those who oppose the killing of whales for consumption may do so for several different reasons. For example, they may be opposed to killing large intelligent mammals because they believe it is cruel to kill them; they may believe that whaling will endanger some whale species or reduce their existence value; and for those who like to view whales, whaling is likely to reduce their chances of seeing whales.

Some of the issues involved can be illustrated by Figure 16.9. There the curve marked DD represents the demand for whales for meat and the curve marked AS represents the supply curve of whales for meat. The curve marked ABC represents the marginal social cost of whaling. For example, the difference between curve BES and ABC might indicate the marginal willingness to pay to prevent whaling of those opposed to it and can be regarded as a marginal externality cost. Although the market would result in X_1 whales being harvested annually, the socially optimal level of harvest is less. It is X_0 if the Kaldor-Hicks criterion is adopted. It is likely to be much smaller if those opposed to whaling have to be bribed (compensated) to allow whaling rather than pay (hypothetically) to have it stopped or reduced. As discussed above, willingness to pay for retention of an environmental good is usually less than willingness to accept compensation for its loss.

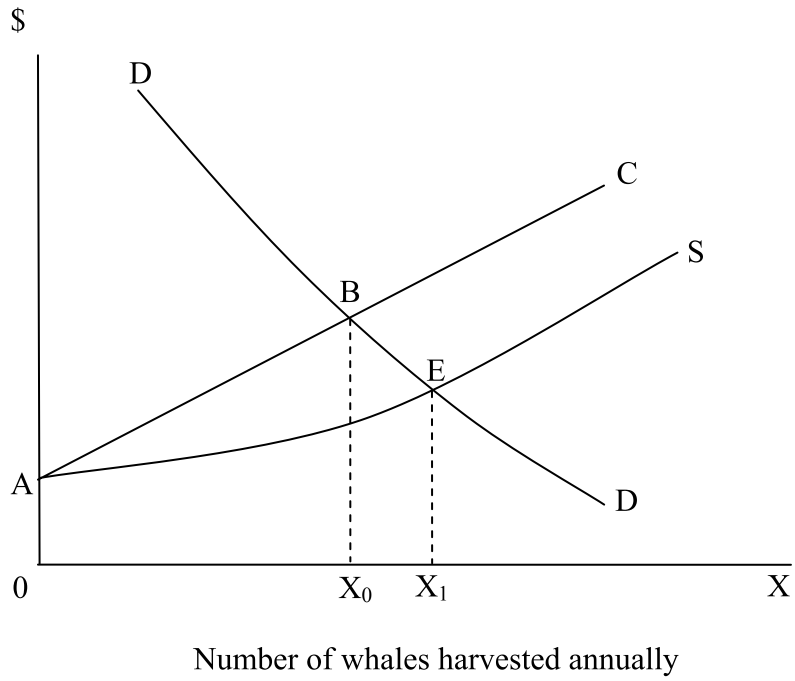


Figure 16.9 An illustration of how an excessive level of whaling may occur if spillover costs from whaling, some of which may be associated with reduction in their non-use values, are important.

Note that it is possible that the social marginal cost curve of whaling may exceed the demand curve for whales for meat. Then even if private harvesting were profitable, no whaling would be socially optimal from a Kaldor-Hicks point of view.

Actually, the whaling case is even more complicated because whales are an internationally shared resource. This is partly because whales travel long distances. In the past, they were also open-access resources and their over harvesting brought several species close to extinction. Let us, therefore, consider the economics of the use of open-access and common property resources.

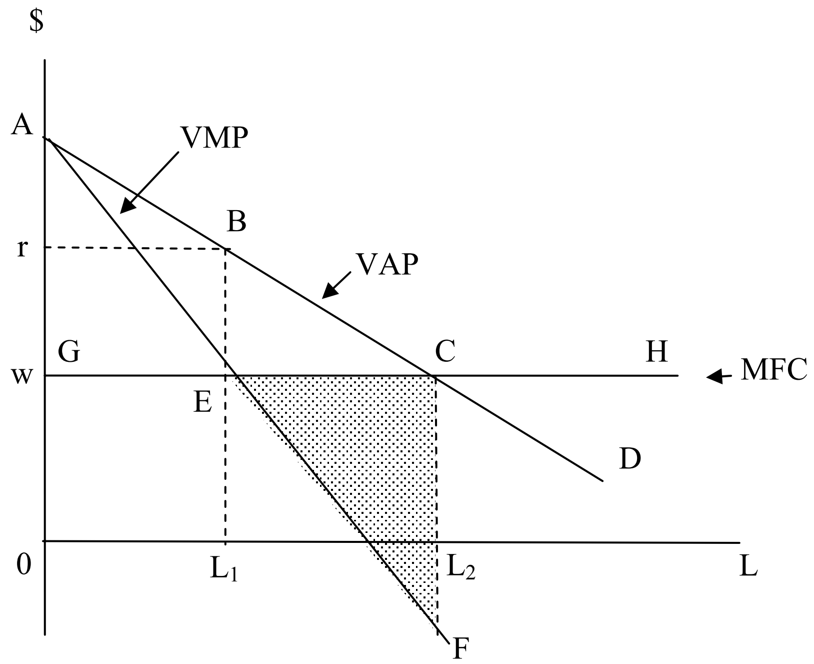
6. Open-access and Common Property Resources.

The types of property rights that exist in resources are important for their economic use. In a perfectly operating market system, individual private ownership will promote efficient resource use in a wide range of circumstances, which include the absence of externalities and of monopoly power. However, the right to use resources is often shared. Individuals in such cases do not have exclusive use of the resources. In various circumstances, this can be a source of economic inefficiency.

An extreme case involves the economic use of open-access resources. These resources are open to all to use but their products become private property once taken by individuals from the open area. Thus if there is open-access to a forest, all can use it but once individuals gather products from it, these become their private property. Similarly, if there is open-access fishing, all have access to it but once fish are caught by individuals they become their private property.

A number of economic inefficiencies occur in the use of open-access resources. In a market system, too many resources are liable to be employed in exploiting open-access resources. Secondly, those exploiting an open-access resource fail to take account of user costs, that is, the benefits of conserving and husbanding such resources for future use. Because user costs are ignored, those harvesting an open-access resource are likely to react in a perverse manner to market signals (such as rising prices) which indicate that the resource is becoming scarce. As a result, instead of conserving the resource, suppliers intensify its use and reduce its stocks. These are not the only possible inefficiencies but they are important ones (Tisdell, 2005, Ch. 6).

In an economy in which some resources are mobile between uses, an excessive amount of resources (from an economic efficiency point of view) will be allocated to exploitation of open-access resources compared to those used in industries in which private property is the dominant ownership regime. This can be illustrated by Figure 16.10. This assumes open-access to a fishery in a particular region but that private ownership of resources prevails elsewhere and perfect competition exists throughout the economy. It is assumed that the mobile resource is labour (or labour plus a fixed proportion of other resources). The quantity of labour allocated to exploiting the open-access resource is designated by L. The wage-rate available to labour in the rest of the economy is w. This is the marginal factor cost of labour and is also equal to value of the marginal product of labour when used elsewhere in the economy.



Quantity of labour (fishers) harvesting fish in an open-access area

Figure 16.10 An illustration of how an excessive amount of resources may be allocated to harvesting an open-access resource

Suppose that the supply of fish from the open-access region does not influence the price of fish and let line AEF represent the value of the marginal product of fish from the open-access region. The corresponding value of average product curve is as indicated by line ABCD.

If the uncaptured fish in the open-access region happened to be private property, then owners of these could charge each fisher r-w to fish. This would result in L_1 labourers (fishers) fishing in the area, and would ensure that the value of the marginal product from labour fishing in the area is equal to the value of the marginal product of labour when used elsewhere in the economy.

However, in the absence of the private ownership of fish in the area, no access fee is payable. Labour will find it economic to catch fish in the area as long as the value of its average catch (VAP) exceeds the going wage rate elsewhere in the economy. Therefore, L_2 units of labour are engaged in fishing in the open-access area. This allocation is excessive by $L_2 - L_1$ from an economic efficiency point of view. It results in a deadweight economic loss equivalent to the area of triangle EFC.

A second type of economic inefficiency occurs because users of an open-access resource consider only their current benefits from using it and take no account of future benefits that may be foregone because of the nature and amount of its present use; they fail to take account of user costs. They do this because if an individual conserves an open-access resource or husbands it, others are likely to benefit rather than the conservationist because anyone is free to take an open-access resource.

The problem can be illustrated by Figure 16.11. There, curve ABC represents the marginal net benefit to users of their current harvesting of an open-access resource and curve OBF represents the marginal user costs of this activity. Users of the open-access resource will harvest X_2 of it whereas a harvest-level of X_1 is optimal when account is taken of user costs. Failure to take account of user costs results in an economic benefit being lost equivalent to the triangular area, BCF.

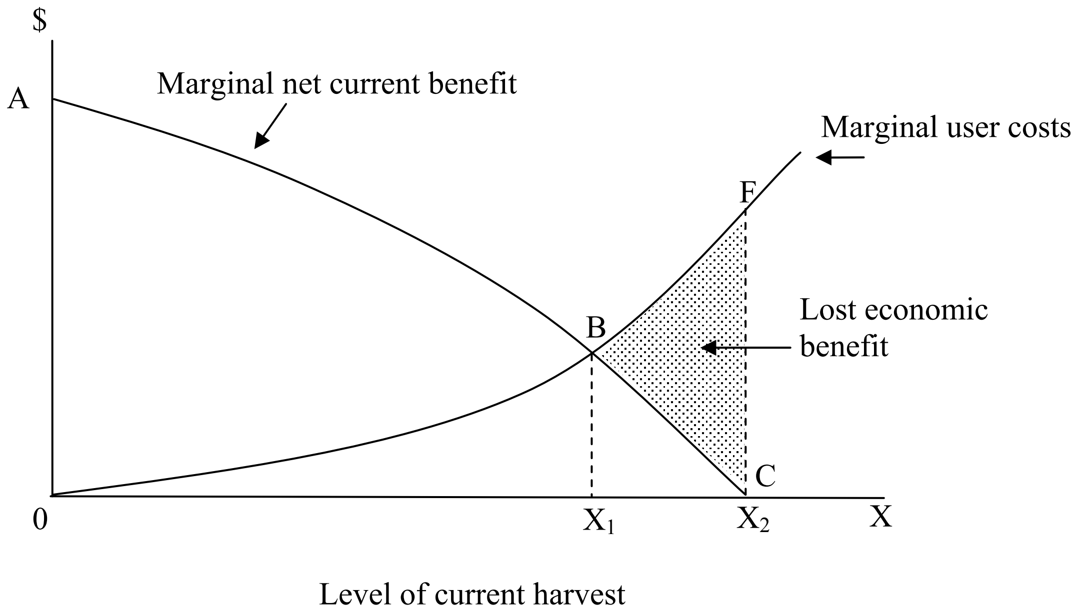


Figure 16.11 Those exploiting open-access resources fail to take account of user costs as illustrated. This is inefficient and adds to future resource scarcity.

If the future value of a resource is expected to rise considerably because the future price of its produce is expected to escalate, this will provide a strong economic incentive to conserve the resource if it is privately owned. However, this is not the case if the resource is an open-access one. The use of an open-access resource is only sensitive to the current price of its produce, not the future price of its produce. If its current price should rise then the current exploitation of the resource will increase (other things constant), even if the economic ideal is to reduce current production so as to increase or sustain future supply. In such circumstances, a species being harvested as an open-access resource may be driven to extinction even when its conservation is optimal from an economic point of view.

Such problems can, however, sometimes be avoided if the use of common-property is subject to communal or social rules governing its use. However, as the group or community subject to such rules becomes larger, enforcement of the rules may become more difficult. If the social rules are habitually flouted the situation becomes in effect one of open-access.

7. Concluding Observations

Some advocates of private property regimes seem to believe that the key to solving inefficiencies in the use of environmental and natural resources is to have them fully covered by a private property regime. However, this view may be unrealistic because it ignores the economics of establishing and maintaining private property rights.

A system based on the institution of private property rights involves costs. These include the costs of identifying ownership of resources and the expenses of excluding others from using resources illegally as well as obtaining compensation from illegal use. These costs will generally be lower in societies where it is customary to respect private property rights. These costs have to be weighed against the economic benefit that owners can obtain by having exclusive use of their property.

The costs of exclusion of those intent upon the illegal use of private property may fall as new technologies are developed that make it easier to enforce exclusion and detect illegal use, and the less costly are legal remedies available to owners who have had their private property rights violated. Furthermore, the economic incentive to enforce private property rights will be greater the higher are the economic benefits expected from such rights. If the costs of establishing and maintaining private property rights are high in relation to the anticipated economic benefits, then it will be uneconomic to have a private property regime. Nevertheless, with economic development there is a tendency for more and more resources to become private property. This is partly a result of technological advances and increasing economic returns from such resources. However, social innovations, for example, in the legal system, which make it less costly to enforce private property rights may also contribute to this result.

It has been observed that some property rights regimes (such as those involving open-access and significant externalities) can add to the scarcity of environmental and natural resources. This problem cannot always be economically solved by extending private property regimes: Coase's preferred option. Therefore, other policies such as resource-use taxes or fees or tradeable-use permits must be considered. In the case of resources including a large public good element, public funding of their provision needs considering. Therefore, it is clear that while extension of private property regimes may solve some environmental and natural resource problems, it is not the key to the solution of all such problems.

Furthermore, while private property rights may help to conserve resources in areas where those rights can be established, it is by no means clear that they will result in an ideal level of conservation of resources in practice, even if externalities and so on, are ignored. This is because the future is uncertain, and individuals and businesses may have a strong preference for short-term economic gains rather than long-term gains. This reduces their incentive to conserve resources. At the same time, economic agents may be unduly optimistic about the possibility that continuing scientific and technological programs will overcome any resource shortages that otherwise would increase with economic growth. The more strongly and widely this belief is held by economic agents the greater is their incentive not to worry about the future state of the environment and natural resource availability and to base their resource-use decisions on very short-term economic benefits. Consequently, user costs may play only a small role in economic decision-making, even in an economy dominated by private property regimes.

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