

2300

ENVIRONMENTAL REGULATION

Michael G. Faure

Professor, The Institute for Transnational Legal Research, Maastricht University

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Abstract

This chapter discusses the economics of environmental regulation by first focusing on the use of cost-benefit analysis in environmental law and policy and in environmental standard setting. Then the various legal instruments to control environmental pollution are discussed as well as the theory of regulation. Also the combined use of regulation and other policy instruments such as liability rules, is discussed. Finally issues of environmental federalism and specific environmental problems such as the nuclear risk and marine oil pollution were discussed.

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1. Introduction

The goal of this chapter on environmental regulation is to provide some insight in the law and economics literature dealing with the policies aimed at solving environmental problems. For several reasons it is difficult to designate the boundaries of this topic. First of all the legal regimes dealing with environmental pollution may be quite diverse, varying from liability rules to environmental taxes or environmental criminal law. Some of these topics will be dealt with in other chapters such as in Chapter 2000 on common property and regulation of the environment. We will try to provide a rather global overview of the law and economics literature concerning the environment, but topics that are explicitly addressed in other chapters will obviously just be touched upon briefly. This is the case for nuisance (Chapter 2100), zoning (Chapter 2200), compulsory insurance (Chapter 2400), pollution tax (Chapter 2500) and several issues relating to liability law (Chapter 3000). Some of these topics, for example liability, law will nevertheless be discussed, especially as far as it concerns literature that is explicitly dealing with the problem of environmental liability.

A second reason why it might be difficult to provide an overview of law and economics literature regarding environmental regulation is that there is, on the

one hand, a large body of legal literature dealing with environmental law, not addressing pollution from an economic point of view and, on the other hand, literature on environmental economics, which studies the effects of economic instruments and the implementation by firms and households. Some of this literature on environmental economics can obviously be of interest to environmental *law* and economics in as far as the legal instruments to implement environmental policy are studied. However, in this literature the various legal instruments to control environmental pollution are usually not the central focus of the research questions. We will mainly try to focus on literature where the acceptability, feasibility, effectiveness and efficiency of various *legal* instruments to implement environmental policy are discussed both from a theoretical and from an empirical point of view. The vast body of literature on environmental economics in the strict sense will therefore not be addressed in this bibliography on *law* and economics.

This chapter discusses the law and economics with respect to 'environmental regulation'. These words often refer to the so-called 'command-and-control' approach to environmental problems in society. Command-and-control regulatory instruments such as environmental standards and targets, together with other administrative obligations and prohibitions are often referred to as 'legal instruments'. This term is then used in contrast to economic instruments, such as taxes or marketable pollution rights. This terminological division is, however, somewhat misleading. Indeed, also liability rules and traditional command and control mechanisms such as for example emission standards are economic instruments in the sense that they will give an incentive to actors to comply with certain policy goals. In addition: the so-called economic instruments are also legal in the sense that a system of ecological taxation or of marketable pollution rights needs a legal framework as well for example determining who should pay how much of a certain tax on what type of activities and when.

It is not easy to indicate which of these policy instruments can be considered as 'environmental regulation', the topic of this chapter. Economists may consider environmental regulation as all government intervention with regard to the protection of the natural environment. This direct regulation, taxation and transfer payments via the liability system would all be considered classical instruments of government intervention from an economic point of view. Lawyers on the other hand would consider liability rules as being different than direct regulation (see also Shavell, 1984a). For the purposes of this contribution, however, both liability rules and other common law instruments are all classified under the name 'environmental regulation' and thus discussed in this chapter.

It might be interesting in this introduction to refer briefly to some of the text books on environmental economics, some of which also discuss the relevance of various legal instruments. We can, in alphabetical order, for example refer

to Ayres (1978), Baumol and Oates (1979), Endres (1985a, 1985b), Field (1994), Frey (1992), Kahn (1995), Kneese (1977), Oates (1996), Pearce and Turner (1990), Portney (1990), Revesz (1997), Richardson, Burrows and Ogus (1982), Tietenberg (1992) and Ward and Duffield (1992).

Furthermore, those interested in an overview of recent literature with respect to environmental economics can be referred to the survey by Cropper and Oates (1992). As far as books on environmental law and economics are concerned, we can, for example, refer to Ackerman et al. (1974) and Eide and Van den Bergh (1996).

The remainder of this contribution to the Encyclopaedia is structured as follows. After this introduction it will be sketched how the basic literature on externalities is applied to the pollution problem (Part A); then we will turn to the importance of cost-benefit analysis for environmental standard setting (Part B). In Part C the various instruments to control environmental pollution will be sketched, including environmental liability and compensation mechanisms. Environmental safety regulation will be addressed in Part D and Part E will be devoted to problems of environmental federalism. Special attention will be given to nuclear liability and regulation of the nuclear industry in Part F. Marine oil pollution issues will be discussed in Part F. A few concluding remarks and points for further research will be addressed in Part G.

A. Pollution as an Externality

2. Coase

In many textbooks on law and economics pollution is presented as the classic example of an externality. A factory might engage in socially beneficial activities such as, for example, the production of pharmaceutical products, but this production process may bring about negative side effects, such as the emission of smoke or waste water. Much of the law and economics literature on environmental law is simply dealing with the two fundamental questions, being

- What is the optimal level of emissions (which will be addressed in Part B)?
- How can the law give incentives to comply with this optimal level?

Traditional economists would answer that the right incentives can be given by imposing a tax on the polluting activity. Since this idea builds on the earlier work of Pigou (1951) this is usually referred to as a Pigovian tax. By equalling the marginal tax rate to the marginal costs caused by the harmful activity the factory would get incentives to reduce pollution in an optimal way. However, in his seminal article 'the Problem of Social Cost' Coase showed that if

transaction costs are zero an optimal allocation of resources will always take place irrespective of the contents of the governing legal rule (Coase, 1960). Coase stressed the reciprocal nature of harm, meaning in this particular case that the pollution is not just caused by the harmful emissions of the factory but also by the presence of neighbours who are, for example, injured through the smoke emissions. The crucial question therefore is not how the law should give incentives to force the factory to reduce emissions. First of all the question should be asked which of the two actors (factory or victims) should be limited in their activity (and maybe the answer is both, if both can take optimal precautions).

If it is, for example, established that the factory is emitting smoke causing a harm of 200 to each of the three victims living in its neighbourhood, that there is no feasible way in which the victims could prevent this harm from occurring and that all the emissions could be reduced by installing a filter which costs 500, the optimal solution is obviously that the filter should be installed. It follows from the Coase theorem that if the conditions are met, the filter will indeed be installed no matter what the contents of the legal rule are. If the law holds the factory liable to pay compensation to the victims, the installation of the filter (which costs less than the compensation payments) is obviously in the interest of the factory. But the same result will hold if the factory is not liable and victims bear their own damage. Given the zero transaction cost assumption they will get together and negotiate with the factory to convince the owners to install the filter. Also if the victims pay for the filter, the price they pay may be less than the costs they would incur if the emissions place.

Obviously, the efficient outcome may not follow if one of the parties behaved strategically or if the zero transaction cost assumption was not met. In addition, it is clear that the Coase theorem only deals with the efficiency aspect of social problems, not with distributional aspects. Indeed, although the efficient result will hold in both cases (liability or no liability), there is a distributional difference: in the first case the factory pays for the filter; in the second case the victims do. Hence, the contents of the legal rule will matter from the victim's perspective. This may be a reason why, from a policy perspective, the legislator sometimes intervenes to make the polluter liable even in situations where the conditions of the Coase theorem were fulfilled.

This Coase theorem is used by many scholars as a starting point for discussing the role of environmental law and, more generally, the need for legal instruments to control environmental pollution. In this respect we can refer to Baumol and Oates (1979), Frey (1992); Oates (1983) and to Schulze and D'Arge (1974). A literature overview is presented by Mishan (1971a). A drawback of the Coase theorem, especially as far as it relates to environmental problems, is that in real life the situation given in the example of one factory emitting smoke that would affect just three victims, rarely exists. Usually there

are cases of multiple victims where transaction costs will be prohibitive. These drawbacks lead to scepticism concerning the importance of the Coase theorem for environmental problems by, for example, Mishan (1971b) and Kapp (1970). In cases where transaction costs are indeed prohibitive, the Coasian negotiations will not take place and some intervention of the legal system will then remain necessary to reach an internalization of the externality.

3. Nuisance

Nevertheless, there are some doctrines in environmental law closely related to the situation discussed in the Coase theorem. Both relate to the important point made by Coase that harm has a reciprocal nature. From this it follows (1) that it is efficient that both actors take precautionary measures to reduce harm. The law should give incentives for such optimal precautionary measures to both injurer and victims and (2) that if there is an incompatible use of property the efficient solution is obviously not always that the factory should relocate. These issues are addressed in the so-called first use doctrine and in nuisance law. We shall not discuss nuisance law here since it is addressed in Chapter 2100 (Nuisance). It is, however, interesting to stress that this reciprocal nature of harm (stressed by Coase) can also be recognized in nuisance law (Epstein, 1993). The law and economics literature of nuisance law generally holds that both actors should face the social costs of their actions: polluters must pay for incremental harm they cause and victims must not be compensated for excessive harm they could have avoided at a lesser cost (Deweese, Duff and Trebilcock, 1996, p. 267). Landes and Posner hold that therefore courts do not award an injunction to stop pollution unless the damage exceeds the costs of abatement (Landes and Posner, 1987, p. 44). This solution recognizes the reciprocal nature of harm.

4. First-Use Doctrine

The first-use doctrine (also referred to as the coming to nuisance defence) relates to discussions that arise when, for example, a factory was located in a relatively empty area and is afterwards confronted with neighbours who 'came to the nuisance' and then claim compensation or even the relocation of the factory. In an *ex ante* perspective these kind of problems should not emerge since citing decisions of firms could efficiently be made looking at the optimal area that is suited for a particular activity. This has been extensively dealt with in the law and economics literature relating to zoning and more particularly in the work of Ellickson (1973). Zoning and land use regulation are explicitly dealt with in this Encyclopaedia in Chapter 2200. From an *ex post* perspective

the law and economics literature, best represented in a paper by Wittman (1980), generally holds the following rules of thumb. If relocation of one of the two conflicting activities is the only way out, one should in principle examine whose costs of relocation are the largest. However, it should also be examined whether the costs of nuisance have already been integrated, for example, in the price paid for the property (next to a railway station). If a much lower price was paid, the externality in fact has already been compensated for and the house-owner cannot claim relocation. Third, the foreseeability of harm is an important criterion as well. The newcomer will have more chances of success if the harmful activities were for example extended in a totally unforeseeable way. Finally, after the decision on who should relocate is made, the question will have to be answered who should pay for the relocation costs. Again foreseeability may be an important criterion in that respect if, for example, many citizens knowingly started building houses close to a factory. Even if relocation costs for the firm would be lowest (and he should therefore relocate) the house owners might have to reimburse the factory for (part of) the relocation costs (see also Epstein, 1979, 1993; Faure, 1994).

5. Cost-Benefit Analysis

5.1 Importance for Environmental Policy

Since we concluded, when discussing the Coase theorem, that in most cases of environmental pollution with multiple victims the zero transaction cost assumption will not be met, some intervention of the legal system will be necessary. Before addressing the variety of legal instruments that can be used to control environmental pollution, the first question to be answered is how the optimal level of pollution should be determined. This question has been addressed from different angles by economists. The starting point is usually the earlier work of Pigou which suggests to impose taxes on a particular activity that should be equal to the marginal social damage it generates. In this Pigovian tradition Baumol and Oates (1971) proposed the use of standards and prices for protection of the environment. Baumol and Oates propose a predetermined set of standards for environmental quality and then advise the imposition of unit taxes to achieve these standards. The appeal of their approach lies in the workability. Baumol and Oates do not need the information that is necessary to determine the appropriate set of Pigovian taxes and subsidies. Although they do not claim that their pricing and standards technique will lead to an optimal allocation of resources, it will reduce the level of environmental damages. In addition they claim that the selection of standards is quite similar to the one already used in public programmes, which should increase the practicality of their pricing and standards approach. This approach has long been the starting point for environmental economic analysis

(see also Schelling, 1983; Tybout, 1972), which approach claims that first a standard of environmental quality will have to be determined (the issue of standard setting will be discussed in further detail below) and then the optimal tax to reach this quality (which is one possible instrument to reach this goal).

However, this approach only provides a partial answer. Indeed, the question still remains how the optimal environmental quality should be determined taking into account a possible conflict with other values. In addition, at the more practical level, the question arises how one should choose between different abatement techniques to comply with the optimal environmental quality. These kind of questions will be answered using cost-benefit analysis, an approach with a substantial history in economics (see, for example, Mishan, 1974a). In environmental policy cost-benefit analysis will be used for example to determine the environmental quality of a certain environmental component, but also to make a trade-off between various abatement techniques. Many authors have shown how traditional cost-benefit analysis can be applied in environmental policy, for example, Ackerman et al. (1974), Oates (1976), Field (1994), Abelson (1979), Cocker and Richards (1992), Tolley, Graves and Blomquist (1981). Nevertheless, there is also criticism on the use of cost benefit analysis from a legal perspective (see, for example, Sagoff, 1981, 1988; Hrezo and Hrezo, 1984; Farber, 1989). Oates (1976, p. 54) pointed out that a cost benefit study involves several essential steps: the first is simply an enumeration of the various forms of benefit costs inherent in the undertaking of for example the clean up of a river. The second step is to assign actual dollar values to the various forms of benefits and costs. The third step involves the selection of a rate of discount for the evaluation of benefits and costs that are expected to accrue in future years. Finally, the present discounted value of the entire expected future stream of benefits and costs will be calculated. In simple words: 'if society is to make the most of its cares resources, it should compare what it receives from pollution control and environmental protection activities with what it gives up by taking resources from other users. It should measure the values of what it gains (the benefits) and what it loses (the costs) in terms of the preferences of those who experience these gains and losses' (Freeman, 1997). The ways of discounting the benefits and costs of environmental regulations are also discussed by Kolb and Scheraga (1990).

Also in public finance since the 1950s public policies have been advocated to control externalities on a marginal cost equalling marginal benefit basis. For this literature on policy analysis see, for example, Friedmann (1984), Stokey and Zeckhauser (1978) and for an overview Rose-Ackerman (1992a). Cost-benefit analysis will obviously also be used when a choice has to be made between various environmental techniques which are all available at different costs and which can all lead to different levels of accident reduction. In an ideal world, incentives would be given to choose the efficient environmental

technique, being the technique for which the marginal costs equal the marginal benefits gained in accident reduction. Requiring a more expensive environmental technique, which could lead to even more reduction of environmental damage, would be inefficient if the marginal costs would be higher than the additional benefits in reduction of environmental damage. With such a balancing process an optimal environmental quality can be determined and optimal environmental techniques can be chosen.

5.2 Limits of Cost-Benefit Analysis

Obviously, this brief sketch of the importance of cost-benefit analysis for environmental policy cannot provide for an indebt discussion of economic theory on this particular point. It seems important to remember that generally economists agree that environmental policy should be based on some weighing of costs and benefits. It is, by the same token, also important to stress that although these principles may be accepted, there is also considerable critique on the use of cost-benefit analysis with respect to environmental problems. One weakness is that a cost-benefit test does not indicate to whom the benefits accrue and who bears the costs (Oates, 1976, p. 56). In other words, it does not take into account distributional matters. More importantly: the question arises how, in environmental matters, benefits of environmental policy can be calculated. One question is whether the benefits will be addressed merely from an anthropocentric perspective by, for example, merely focusing on a reduction of risk to human health or from an ecocentric perspective. Another question is how benefits should be measured if they concern a reduction of a possible threat to an entire ecosystem. The question arises whether the traditional 'willingness to pay' test, which relies on market criteria, suffices to value environmental damage.

5.3 Cost-Benefit Analysis in Environmental Law and Policy

An important part of the remainder of this contribution will be devoted to the question how the law can give incentives to adopt an environmental policy (at government and at individual firm level) that corresponds as much as possible with these principles of weighing marginal costs versus marginal benefits. It might be interesting to mention that increasingly cost-benefit analysis is referred to at the policy level. In the recent work of Sunstein (1993, 1995, 1996b) and Ogus (1995, 1997) it is claimed that policymakers generally, but also with respect to environmental policy, should take cost benefit analysis into account in policy design. Cost-benefit analysis is obviously also used for example to analyse whether the benefits of superfund cleanups justify the costs, a question addressed by Gupta, Van Houtven and Cropper (1995).

Finally, we can point at the fact that environmental law generally seems to rely increasingly on notions such as ALARA (As Low as Reasonably

Achievable), BPM (Best Practicable Means), BPEO (Best Practical Environmental Option) and BATNEEC (Best Available Technique Not Entailing Excessive Costs). Ogus claims that these notions aim for socially optimal levels of pollution where the marginal social costs of pollution abatement are roughly equal to its marginal social benefits (Ogus, 1994b, p. 207). Faure and Ruegg (1994) claim that the BATNEEC notion by its reference to the avoidance of 'excessive costs' refers to the marginal costs/marginal benefit test. Thus, the BATNEEC notion allows for more efficient environmental standard-setting and for an explicit application of the economic model. The BATNEEC notion (or varieties of it) can now also be found in European legal documents, such as the recent directive on integrated pollution prevention and control (see a discussion by Faure and Lefevre, 1996).

Moreover, the use of cost-benefit analysis is often advocated by economists in order to choose those policies which minimise costs for society. Cost-benefit analysis can, for example, play a role prior to a regulatory intervention to assist in choosing the most efficient policy. This area of research, which is in fact a direct application of the law and economics approach, is referred to as the 'economic analysis of environmental regulation'. Some of the work in this area includes the design of models for policy analysis; other work is more practical and looks at the costs associated with alternative policy options. Arnold (1995) provides a good overview of the issues at stake.

6. Environmental Damage Assessment

This brings us to an important second topic related to the pricing of environmental pollution. The valuation of environmental damage is obviously important for the just mentioned cost-benefit analysis, but also when the compensation due in a tort case has to be established. Economists have established a variety of techniques for valuing environmental damage. One method is the so-called hedonic price technique. This is based on the analysis of market data from transactions in private goods and services which are related to the characteristics of the public good under consideration. In other words, in the hedonic price technique the value of changes to the natural environment are analysed by the perceived monetary changes this has caused in markets of influenced goods. It is then, for example, assumed that housing values would reflect the variation in the quality of environmental goods. House prices can be a function of natural surroundings such as the presence of parks and forests. On that basis an evaluation of environmental improvement could be undertaken based on an estimation of the house price function. This approach has, for example, been applied by Hoch and Drake (1974), Harrison and Rubinfeld (1978) and Nelson (1978) and for a critical analysis Maler

(1977). The alternative is to ask individuals to state their willingness to pay for environmental improvement directly, using a survey questionnaire. This is referred to as contingent valuation and is based on a hypothetical allocation procedure for the particular public good. This more direct approach is based on, for example, Davis (1963), Bradford (1970) and Bohm (1971) and for a comparison of both methods of analysis see Pommerehne (1988). There is a lot of discussion of contingent valuation in the US since it is being used under some environmental laws (see for a critical analysis Hausman, 1993). Another option is the use of travel cost studies to estimate environmental benefits. Travel cost studies have been used to measure the benefits of recreational options (see, for example, Krutilla, 1967).

General attention to methods of valuing environmental damage is also given in the work of Kapp and Smith (1992), Johansson (1990) and Pearce (1976a, b). Recently a lot of attention has also been paid to the interests of future generations and the question how some kind of intergenerational equity can be taken into account in environmental valuation (Krutilla and Fischer, 1985). Howarth and Norgaard (1992) showed that the valuation of environmental services and how society cares for the future are interdependent. They claim that the valuation of non-market goods and social objectives are intertwined.

B. Environmental Standard Setting

7. Target Standards

The further question to be addressed is how the above discussed cost-benefit analysis can be used to set legal standards efficiently. This is the problem of environmental standard-setting. It seems appropriate to state from the outset that one has to distinguish between various different standards, in order to avoid confusion. When economists discuss standards (such as Baumol and Oates in their classic paper on 'The Use of Standards and Prices for Protection of the Environment' 1971) they usually refer to what is called in legal terms a target standard or a quality standard. This standard defines the optimal environmental quality for a certain environmental component and is also referred to as an ambient standard. This can take different forms. The quality standard could very broadly state how for example a particular habitat should be shaped in an optimal ecological way, or it should simply refer to specific chemical parameters to which for example the water in a creek should comply. As we have explained above, economists have traditionally argued that the law should limit itself to set these targets, whereby the instruments to reach these targets should be incentive-based (see in addition, Schultze, 1977). When lawyers refer to standards, they usually refer to the regulatory measures, usually used and imposed by administrative agencies, that prescribe what measures a

factory causing an externality should take to prevent harm. These measures can be imposed in general rules, but can also be found in individual licenses. In the environmental area they will often take the form of emission standards, prescribing the particular quality and quantity of the emissions into the environment. Non-compliance with such standards is usually enforced with administrative and/or criminal sanctions. Since in that particular case the actor is not free to choose the measures he wishes to use, to reach an optimal environmental quality, this approach is by economists often referred to as the 'command and control' approach. In order to avoid this confusion concerning the notion of standards we shall, following the work by Richardson, Ogus and Burrows (1982) distinguish between three types of standards: target standards, emission standards and production standards. The first ones are the target standards, which are often referred to as ambient quality standards. They specify the environmental quality as such, being how much of each pollutant may be present in a particular environmental component. Ogus (1994a, p. 28, 1994b, p. 208) points out that these quality standard may not entirely solve the information problem. If the harm is not closely connected to the activity, the agency costs of determining the causal connection may be very high since the harm may also result from other activities. Target standards are therefore generally in the first place addressed to the standard-setting agency.

8. Emission Standards

A second type of standard often used in environmental policy is the emission standard. These standards still leave some freedom to the potential polluter, since they usually only determine (in general rules or individual licenses) the amount and quality of the substances that can be emitted into the environment. There is obviously less freedom than with mere quality standards. Quality standards would leave it completely up to the firms how to comply with the target set. When emission standards are used, the quality and quantities of the emissions are regulated. Still, emission standards leave more freedom than the third category, production standards. These standards, which are also referred to as specification standards, regulate at an early stage of the production process by, for example, determining what kind of production technology will have to be used by the firm. The disadvantages of the latter standards are obvious: they may become obsolete very rapidly, delay technological changes and may have significant anti-competitive effects (see Ogus, 1994a, p. 29, 1994b, pp. 209-211; Stone, 1980; Stewart, 1981).

In legal practice one could traditionally mostly find emission standards (the traditional command and control approach). They have been criticized from an environmental point of view, since by merely focusing on individual emissions

of separate firms, an agency would not envisage the effects of the overall pollution on the specific environmental component. This problem could be remedied if the total number of firms is known and there are no expected new entries. This shows that emission standards are therefore momentary static instruments. The overall pollution can no longer be controlled by emission standards as soon as the market situation changes. Moreover, emission standards as such gave little incentives for innovation in abatement technology and further reduction of environmental harm. The innovative effects of various policy instruments are discussed by Downing and White (1986). Policy therefore changed to an increasing use of target standards, but in many countries the target (or ambient quality) standards did not replace the emission standards. In fact, ideally first the optimal environmental quality is determined and afterwards the emission standard of the different firms are fixed in such a manner that the aggregate pollution coming from the various emissions will not exceed the environmental quality standards set. The case for specification standards is generally weak, unless the standard setter has better information than firms concerning the optimal production technology or innovation activity, which is, however, unlikely to occur (Ogus, 1994a, p. 29).

Ideally, one would therefore find target standards defining the environmental quality and, depending upon the implementation instruments chosen (see Section 4) possibly emission standards as well. These emission standards should indeed not necessarily take the form of regulatory standards of the command and control type (for example in licenses), but could also be implemented in emission taxes or take the form of the due care standard in a liability case.

9. Standard-Setting and Cost-Benefit Analysis

The question arises how the cost-benefit analysis discussed above fits into this standard-setting scheme. Cost-benefit analysis will first of all play a role when environmental targets are determined, as has been indicated above. But also at this second stage of defining emission standards, will cost-benefit analysis play a role. In an optimal world where the regulators set emission standards in the public interest, the administrative agency will take into account the marginal costs of more stringent environmental standards and balance these against the marginal benefits from additional reduction of environmental harm. This refined balancing process requires accurate information both on the expected environmental harm and on the marginal costs of the various technical devices that could prevent this harm (and on the corresponding emission standard). Depending on whether either the parties in the market setting or an administrative agency can be assumed to have the best information this will

lead to a choice for fixing emission standards via tort law (in which case they will correspond with a due level of care) or via regulation (in which case they will be incorporated as a condition of the administrative license).

Obviously, a large body of literature had addressed the efficiency of various emission standards, especially comparing the traditional command and control approach with more incentive-based systems to reach an environmental quality. Oates, Portney and McGartland (1989) pointed out that incentive-based policies are not necessarily superior to command and control approaches. This is more particularly the case when command and control approaches are designed with at least one eye on cost savings and when the overdeterrence results in other compensating benefits. This outcome is particularly true if economic analysis plays a considerable role in command and control standard-setting. If cost-benefit analysis is indeed applied in environmental standard-setting many of the inefficiencies may disappear and outcomes can be produced that compare quite well with incentive-based alternatives. Another example is provided in a paper by Stephan (1988), who also argues that (1) emission standards have important distributional effects; (2) they lead to a significant reduction of waste water emissions; and (3) they encourage implementation of less polluting production techniques in the long run.

10. Principles of Environmental Law

To conclude this discussion of the importance of cost-benefit theory for environmental standard-setting it might be interesting to contrast the economic approach with recent evolutions in environmental law. We already pointed out that the recent use of general principles of standard-setting, such as BPM, ALARA and BATNEEC, seems to allow for an increased use of economic methodology in the environmental standard-setting approach. There is, however, another tendency in environmental law that might be somewhat in contrast with this increased attention for cost-benefit analysis. In international documents, such as the RIO declaration, Agenda 21 and the EC Treaty as it has been modified by the Treaty of Maastricht, several general principles of environmental law are incorporated. The status of these principles is still somewhat unclear; they are probably more policy orientations than binding legal texts. Some of these statements, however, seem to depart from the economic principles of environmental law. One clear example is the attention which is given to the so-called polluter pays principle. This is, for example, incorporated in art. 130r al 2 of the EC Treaty. Taken literally it could mean that a firm would in all cases be forced to compensate for environmental harm, irrespective of the behaviour of the victim and irrespective of the costs associated with precautionary measures. Adams (1989) clearly pointed out that

this principle is an empty shell which offers little help at the policy level. Boyd and Ingberman (1996), however, recently examined whether this principle implies that liability should be extended if the polluter can not pay.

The same inefficiency might arise with another principle that currently receives a lot of attention in environmental legal doctrine. This concerns the precautionary principle, which is equally incorporated in art. 130r al 2 of the EC Treaty. Ogus (1995) correctly pointed out that this may force regulators to issue regulation even when the benefits of such a regulation are unknown since there is no information on possible harmful effects, providing another example where these legal principles may collide with economic analysis.

C. Instruments to Control Environmental Pollution

11. Introduction: Various Possible Policy Instruments

11.1 'Economic' versus 'Legal' Instruments

After having discussed how the optimal amount of pollution can be determined from an economic point of view, we shall now turn to the question what kind of legal instruments can be used to reach the goals set. In this part of the contribution a general overview of various possible instruments will be provided and some attention will be given to environmental taxes and tradeable permits. The subsequent parts will specifically address the role of environmental liability (Sections 14, 15 and 16) and environmental regulation (Part D). In the economic literature, based on Pigou's work, a variety of so-called 'economic' instruments have been advocated. It is essential with most of these economic instruments that they do not prescribe directly (as in the command and control approach) what the behaviour of potentially polluting firms should be. Principally the basic idea is that a tax should be attributed to the polluting activity, so that the pollution caused is represented by a certain price. The tax, that is, the price for the pollution, would then be calculated by the firm in the price of its products. The market mechanism would then give incentives for investments in optimal abatement techniques. Firms that refused to invest in abatement techniques would cause higher pollution thus be subjected to a higher tax, and through the market mechanism would price themselves out of the market. This is a simple summary of the basic ideas underlying the literature which is advocating the use of incentive-based instruments in environmental policy. More particularly Schultze (1977) has advocated that the government should reach more of its policy goals by using incentive based instruments. In addition there was the belief that by using the market mechanism the policy goals could be reached more easily than through the classic command-and-control approach (see, for example, Moore, 1989 et al.; Ackerman and Stewart, 1988; Stewart, 1988). However, we already

mentioned above that there is some literature that sheds doubt with respect to this assumption.

Before addressing the variety of instruments that can be used in environmental policy (as has been done for example by Dewees, 1983a, 1983b and Helm and Pearce, 1990), we should first point out that when economists refer to 'economic instruments' they usually mean incentive-based mechanisms, such as taxes or marketable pollution rights in contrast to 'legal instruments' which would be the classic command and control mechanisms.

The basic difference is indeed that the instruments usually referred to as 'economic' are incentive-based, meaning that the policy goals (for example the ambient quality) are set, but that the ways to reach this goals are (more or less) left up to the regulated. It does not seem worthwhile to discuss this terminological question any further. The reader should just bear in mind that economists and lawyers might attribute a different meaning to the wordings 'economic' versus 'legal' instruments. It is, on the other hand, useful to provide a short overview of the variety of instruments that can be used to reach environmental policy goals and which are discussed in the literature and actually in practice as well.

11.2 Common Law Remedies

Starting from the assumption that the Coasian conditions are not met because of prohibitive transaction costs, one could first look at common-law instruments that are relatively broad, easy to administer and applicable at relatively low costs. One should in this respect in the first place obviously point at the importance of property rights in providing protection against environmental pollution. Traditional common law as well as civil law views most conflicts whereby for example a factory emits smoke causing harm to neighbours as an infringement on the property rights of neighbours. This may give rise to a nuisance which can give the victim a right to claim the cessation of the harmful activity via an injunction.

Another related and, in the field of environmental law probably at least as important, common-law instrument is liability law. Liability law can, from the victim's point of view, provide protection against torts committed by the factory. In this case, factory and victim need not necessarily be neighbours and the traditional remedy in case of tort law is compensation. The boundaries between property rights and liability rules have been discussed by Calabresi and Melamed (1972). Although the role of liability rules is rarely discussed in the environmental economics literature when policy instruments are discussed, there is an important body of literature in the economics of accident law, starting with Calabresi (1961, 1968), Posner (1972) and Shavell (1980b) which shows that liability rules can give incentives to the actors in a potential accident setting for efficient behaviour. As we shall discuss below, environmental

liability is now used as one of the important legal instruments to deter environmental pollution. It is still an instrument that leaves a lot of discretion to the actors involved. Depending on whether a strict liability or a negligence rule applies, basically either the firm itself or the court system will determine the due care required in the legal system which can in an environmental case, for example, refer to an optimal abatement technique. Since neither the abatement technique itself, nor the following emission standard, will be determined *ex ante* by a regulator, the liability system is often referred to as a market-oriented approach, for example by Calabresi (1985).

11.3 Incentive-Based Mechanisms

However, in many cases the deterrent effect liability rules can give will not suffice in case of environmental pollution given information problems (see Part D below). This has led economists to propose a variety of incentive-based (or 'economic') instruments varying from taxes to subsidies and a variety of 'pollution rights models'. In alphabetical order one can refer to the following literature: Ackerman and Stewart (1988), Anderson (1978), Breger (1989), Hahn and Stavins (1991), James, Janssen and Opschoor (1978), Moore et al. (1989), Nichols (1984), Schelling (1983) and Tietenberg (1990). It would go beyond the scope of this contribution to discuss the importance of this literature here. Furthermore we will discuss some of the literature concerning taxes on the one hand and tradeable pollution rights on the other hand below. For now we can simply refer to these economic instruments as measures that do not impose a direct legal constraint on the supplier's behaviour; these measures rather function as incentives, conferring financial advantages or disadvantages on certain activities (Ogus, 1994b, p. 27).

11.4 Regulatory Standards

Another category of possible instruments relates to the standards discussed above in Part B. They can be considered as regulatory in the sense that the actor who fails to meet a certain standard shall be confronted with an administrative or criminal sanction. Another type of regulatory intervention would be prior approval (Ogus, 1994b, pp. 26-27, pp. 214-244). In that case the interventionism again goes further than in the case of mere standards. Standards do allow the activity to take place without *ex ante* control, whereas prior approval requires the firm to have, for example, a license before the activity itself can be undertaken.

11.5 Voluntary Compliance

Finally, one could conclude this list of tools for environmental policy by referring to, for example, voluntary compliance through moral persuasion,

although economists are somewhat sceptical about the efficacy of such an approach (Oates and Baumol, 1975). In addition we should refer to the work by Menell (1991) who points at the inherent limits of legal institutions in controlling environmental risks.

11.6 The Choice of Instruments

Concluding this overview of possible instruments of environmental policy, we should first of all stress that there is an abundant literature concerning the choice of a particular instrument to control a specific externality problem. This literature discusses comparative benefits of various instruments in a given situation. Polinsky (1979) built on the Calabresi/Melamed model which discussed property rights and liability rules by adding the tax-subsidy approach to the comparison between property rights and liability rules. Polinsky argues that when the government has full information about the externality problem, only the tax-subsidy approach can both control the externality efficiently and protect both parties' entitlements. This remains the case also in a positive transaction costs world. Polinsky also addresses the more realistic setting in which the government has limited information. In that case the approaches can be ranked to some extent. He claims that the tax approach will be inferior to the liability rule approach in a wide range of circumstances, but that in terms of entitlement protection there is a clear preference for the property right approach. A comparison of Pigovian taxes and the liability rule approach is also provided by Brown and Holahan (1980). The analysis is further extended by White and Wittman (1981) by addressing both liability rules and zoning to control pollution. A lot of attention has also been given to the trade-off between liability rules and regulation; this literature will be discussed in Part D.

Most of this literature advances criteria for the optimal use of a specific policy instrument. However, the ideal conditions for one specific instrument will almost never all be met at the same time. Hence, in actual policy one will notice that environmental law is usually based on a combination of a variety of instruments such as property rights, liability rules, emission and target standards as well as a variety of taxes. This complies with law and economics literature in which a combined use of instruments has been studied, for example Hansson and Skogh (1987) and Skogh (1982, 1989b). A combined use of taxes, liability rules and insurance has been examined by Gravelle (1987). Also with respect to liability rules and regulation a combined approach has been advocated, which will be discussed below. Generally, differences between a 'pricing' and a 'sanctioning' approach have been examined by Cooter (1984).

12. Tradeable Permits

We shall now pay some attention to two specific economic instruments, being tradeable permits and environmental taxes. These merit some further remarks given the attention they have received in the literature and, to an increasing extent, also in environmental policy. The starting point for most of the literature on tradeable systems is the pioneering work of Dales (1968). Dales proposed that a market of tradeable permits would be organized by the government whereby pollution rights that should be tradeable would be granted for a certain period. The government would act as broker for the trade and would monitor the system. Building on Dales's proposal other authors formulated more specific proposals with respect to the shape of this market for pollution rights. Montgomery (1972) suggested that the pollution right should also indicate which part of the concentration of a specific compound in a particular environmental component could be emitted from a particular source. Further proposals concerning the implementation of such a model have for example been formulated by Ackerman et al. (1974), Rose-Ackerman (1977) Noll (1982) and Tietenberg (1985). Hahn and Hester (1989) pointed at the importance of monitoring and enforcement in the framework of a market for pollution rights.

In addition to these papers sketching the theoretical benefits and the possible legal framework of a market for pollution rights many subsequent contributions have analyzed how some of these ideas have been implemented into environmental policy. Although most of the success stories in that respect come from the US, there is also a (modest) European experience with (some forms of) tradeable pollution rights. For instance in the Netherlands, Peeters (1992) discusses in her dissertation Dutch manure legislation which allows for a trade in the right to produce manure. As far as the US is concerned, the empirical material relating to the experience with transferable permits is overwhelming. Making an arbitrary selection, we can, for example, refer to the work of Oates (1986) who discussed the emissions trading system for air pollutants and reports that trading has made real headway in certain regions. With equal enthusiasm he reports on the success of a system of transferable discharge permits in Wisconsin, noting that even several European countries are closely following the US experience with transferable emissions entitlements (see also Oates and Collinge, 1982; Oates, Crupnik and Van de Verg, 1983; Oates and McGartland, 1985a, 1985b). His enthusiasm is supported by other sources. Hahn and Hester (1989) claim that the trading programmes concerning the Clean Air Act have led to considerable cost savings, albeit it that they had been less than anticipated. However, they also claim that it is hard to demonstrate major environmental improvements as a consequence of these market policies. Indeed, trading may have increased emissions in some cases where the pollution rights that were sold were previously not being fully utilized by the owner (see also Dewees, Duff and

Trebilcock, 1996).

13. Environmental Taxes

Finally, we can briefly refer to the findings in some of the literature on environmental taxes. This is just for sake of completeness; pollution taxes are discussed in more detail in Chapter 2500. We mentioned earlier, discussing economic instruments generally, that the case for pollution taxes has been made since the early work of Pigou. Instead of focusing on the known literature that defends the importance of taxes from an economic point of view, it is more interesting to look at empirical results. As far as theoretical papers advocating environmental policy to be based on a tax system are concerned, we can refer to the papers mentioned above. The classical economic literature on environmental taxes in the Pigovian tradition has recently been taken one step further by Paulus who examined the feasibility of ecological taxation, examining how the whole taxation system could be ecologically reshaped (Paulus, 1995).

As far as empirical material relating to experiences with taxes is concerned, it is remarkable that much more evidence seems to come from Europe than from the US. This was typically the reverse for the marketable pollution permits which were apparently more popular in the American experience than in Europe. Dewees, Duff and Trebilcock (1996, p.326) note that charges are rarely introduced 'in the text book form'. Hahn (1989a), moreover, claims that most emission charges or fees are used as a revenue generating device for public services rather than instruments of environmental policy, as they were prescribed by economists. The reason why taxes are relatively rarely used in the US are also discussed in a report drafted by Oates (1994) for the OECD. Most empirical evidence concerning the effectiveness of environmental taxes and charges come indeed from Europe. Dewees, Duff, Trebilcock (1996, p. 326) argued that in the Netherlands water pollution by 14 industries responsible for 90 percent of total water pollution decreased by 50 percent between 1969 and 1975 and by another 20 percent by 1980, whereby half of this reduction was due to the effluent charge. Similar success stories come from Germany (Braun and Johnson, 1984) that due to water effluent charges there were significant increases in water treatment leading most of the firms to comply with the existing emission standards. Since Germany (as most European countries) still has a combination of effluent charges and emission standards, it is hard to argue that the significant investments in water treatment plans were mainly due to the charges system and not, for example, to the threat of administrative and/or criminal sanctions in case of violation of emission standards. These findings concerning the success of effluent charges in Germany comply with reports by Frey who argues that the environmental taxes lead both to a

considerable reduction of emissions into the aqua system and into the air (Frey, 1992, pp. 149-151). We can finally point at a study by Bongaerts and Kraemer (1987) comparing water pollution charges in France, the Netherlands and the Federal Republic of Germany, coming to the same conclusion that effluent charges provide a strong incentive to invest in water pollution abatement equipment, but that it is impossible to disentangle the separate effects of charges and emission standards. The latter effect is especially strong in Germany where the charges are halved for emitters who meet the effluent standards.

14. Liability Rules

14.1 Negligence versus Strict Liability

One of the instruments of environmental policy which has received relatively little attention in the environmental economics literature is tort law. There is an impressive body of literature on economic analysis of accident law (which will be discussed in Chapter 3000) which has shown that tort rules may have two goals. The first, which is often stressed by lawyers, is the compensation of victims of accidents; the second, usually more stressed by economists, is the deterrent function of tort rules. Indeed, since the pioneering work of Calabresi (1961), Brown (1973), Posner (1972) and Shavell (1980b) economists have stressed the steering function of liability rules. The foresight of being held liable *ex post* will induce parties in the accident setting to take optimal care. These basic ideas, which are further developed in other chapters (3000, 3100) in this volume, can also be applied to environmental damage. By using liability law a potential polluter can be given an incentive not to pollute or to invest in cleaning equipment of which the marginal costs equal the marginal benefits in reduction of additional environmental damage. In other words, the cost-benefit test, described in Section 3, can also be translated into, for example, a due care standard in tort law. Many authors have applied these general notions of the economics of accident law to environmental liability and have shown that also in the environmental context tort rules may have this preventive effect (see Michelman, 1971; Bouckaert, 1991; Endres and Staiger, 1996; Faure, 1996). A nice study on a Swedish environmental liability case has been presented by Skogh and Rehme (1998). Since the details of the economics of tort law are discussed elsewhere we shall now only focus on a few aspects of particular importance for environmental liability from a law and economics angle.

One crucial question (also addressed in Chapter 3100) is whether environmental liability should be based on strict liability or on a negligence regime. The economic literature generally accepts (Shavell, 1980b, 1987b, p. 8) that both a negligence rule and a strict liability rule will provide a potential polluter with incentives to take an efficient care level. However, if the activity

level is also taken into consideration, a negligence rule will not be optimal since the activity level is not incorporated into the due care standard which the courts apply. Hence, it is argued in the literature that in a unilateral accident model (whereby only the behaviour of the injurer influences the accident risk) strict liability will be efficient since it leads both to efficient care and to an optimal activity level. Hence, it has often been argued in the literature that there seems to be an economic rationale behind the tendency in case law and environmental statutes in many legal systems to introduce strict liability for environmental damage: since the victim cannot influence the accident risk, strict liability will be first best to give the potential polluter optimal incentives for accident reduction and, hence, for optimal internalization (see, for example, Endres and Staiger; 1996, Faure, 1995a and for nuclear liability Faure, 1995b). However, if risk aversion of the polluter is assumed, strict liability is only efficient if it is insurable (Endres and Schwarze, 1991).

14.2 Damage

A second crucial aspect in environmental liability is the determination of damage. We already mentioned earlier that classic techniques for valuation of damage will be hard to apply when, for example, an entire ecosystem is endangered as a consequence of certain emissions. Nevertheless a more or less accurate estimation of the damage seems important for several reasons. First of all the scope of the environmental harm will have a large influence on the optimal level of care required from the potential polluter. Indeed, there is supposed to be a relationship between the magnitude of the harm and the optimal level of care. Hence, it seems important to have some insight in the amount of the damage to be able to fix the level of care required from a potential polluter in an efficient way. Second, for the same reason it will be important to fix the magnitude of the harm accurately *ex post*, not only to provide a fair compensation to victims (although it may not always be clear who they are in an environmental case), but also because this fixing of the magnitude of the damage will have an influence on future cases as well. We have already indicated that economists have developed various techniques to evaluate environmental damage in the discussion in Section 6.

14.3 Causation

A third issue of particular importance in environmental liability is causation. Again we can refer to the general discussion of causation issues in Chapter 3300 and address just a few aspects of particular importance for environmental liability. In environmental liability the problem will often arise of uncertainty concerning the causal link between an event (for example an emission) and a certain outcome (for example health damage). The question then arises how one should deal with this causal uncertainty if scientific evidence for example

reports that there is a 40 percent probability that a certain cancer was caused by the wrongful act, but a 60 percent probability that the cancer came from another source (the so-called background risk). After early law and economics papers where the importance of the causation issue was stressed (for example Calabresi, 1975; Shavell, 1980a and Landes and Posner, 1983), further studies explicitly addressed the problem of causal uncertainty. Shavell (1985) and Kerkmeester (1993) stressed that in case of causal uncertainty the liability of the injurer should be limited to those cases in which he actually caused the harm. Otherwise liability would be experienced by the injurer as 'crushing' or, in economic terms, over-deterrence would take place. This would result if in our example, the firm would be held to pay 100 percent damage even though there was only a 40 percent probability that his activity contributed to the harm.

Rosenberg (1984), Kaye (1982) and Rizzo and Arnold (1980, 1986) have argued that there should only be liability to the extent that the activity contributes to the accident risk, meaning that on the basis of statistical evidence the liability rule should be constructed in such a way that the polluter will never be held liable for the background risk (which he did not cause), but only for the so-called excess risk (the contribution of his activity to the risk). The question then arises what kind of legal rule can respect these principles. Traditionally there are two possible rules. One possibility is to award 100 percent compensation to the victim once a certain threshold is passed, for example a 50 percent probability of causation. This is called a threshold liability. This rule, which was applied in the US for a long time, is considered to be inefficient and also unjust since it will force a firm to compensate (at least partially) for damage which it can never have caused from a statistical point of view. The alternative is to translate the probability of causation by awarding the victim a proportion of its damage. When the chance, as was the case in our example, is 40 percent that the harm was caused by the tort, the victim will be awarded 40 percent of his loss. The advantage from an efficiency point of view is that the injurer is precisely exposed to the excess risk which he caused. This rule may also be preferable from the victim's perspective, since in this case he would have received nothing under a threshold liability, since the 50 percent threshold was not passed. The threshold liability is indeed an 'all or nothing' approach. Economic analysis generally holds that only the proportional liability rule will give optimal incentives for accident prevention (Landes and Posner, 1984; Robinson, 1985; Makdisi, 1989 and Faure, 1993).

Causation issues and more particularly causal uncertainty will play a crucial role in many of the cases involving environmental harm. In many legal systems attempts are made to circumvent causality problems by imposing joint and several liability rules. This is, for instance, the case under the American 1980 Superfund Statute. This may be problematic as far as the incentives for accident prevention are concerned, although joint and several liability may promote

settlements, thereby reducing litigation costs (see Kornhauser and Revesz, 1995a, p. 49). The economics of joint and several liability has also been analysed by Tietenberg (1989).

Also in European cases concerning environmental liability questions of causal uncertainty have arisen, for example concerning the drug DES. With respect to the uncertainty with which the manufacturer sold the specific product to a particular mother, the question arose whether a type of proportional liability rule should be applied to apportion the burden of liability between the manufacturers (a market share liability). The Dutch Supreme Court, however, applied a joint and several liability rule (see Spier and Wansink, 1993). Another example relates to the employer's liability for occupational diseases. In another Dutch Supreme Court case a victim of asbestosis could not prove at what time he had been confronted with the fatal asbestos crystal which had caused his disease. The Supreme Court once more shifted the uncertainty risk concerning causation to the enterprise by holding that it was presumed that the employee had been confronted with the fatal asbestos crystal during the period of his employment for the defendant (Faure and Hartlief, 1996a). Causal uncertainty also played a role in the famous British Sellafield case where an English Court had to decide on the causal relationship between childhood leukaemia and the nearby presence of a nuclear power plant at Sellafield (Gardner, 1990). For a discussion of these cases of causal uncertainty, see Faure and Hartlief (1996a).

14.4 Financial Caps

A fourth feature of many environmental liability regimes, especially under international conventions, is a limitation of the compensation. This is usually justified on insurance grounds. Nevertheless, these financial caps have been seriously criticized both in legal and in law and economics literature. Lawyers argue that caps seriously limit the rights of victims to full compensation. From an economic point of view this is a problem as well since there will be no full internalization of the risky activity. Furthermore Landes and Posner (1984) have argued that if the statutory limit is lower than the potential magnitude of the accident, a problem of underdeterrence will arise. Moreover, insurability should not be an argument to introduce financial caps in environmental liability legislation. Liability can be unlimited and a possible duty to insure may be limited to an uninsurable amount (Faure, 1995b).

14.5 Latency and Retroactive Liability

A fifth point concerning environmental liability relates to uncertainty over risk. In environmental liability there is often a long time lapse between the harmful emission and the moment that the damage occurs. This caused an intense debate, especially in the field of soil clean-up liability concerning the question whether liability rules may be applied in a retroactive manner. This relates to

the question whether the damage needs to be foreseeable, discussed in Chapter 3300. As far as environmental liability, more specifically soil clean-up liability is concerned, the law and economics literature generally holds that a retroactive application of new standards either through case law or through regulation could never affect incentives for future behaviour of the specific operator and is therefore usually to be considered inefficient. This statement may, however, be different since the foresight that there may be liability *ex post* even for risks which are not known at the time (the so-called development risk) may give incentives to obtain information about that risk (Shavell, 1992; Visscher and Kerkmeester, 1996).

15. Insurance of Environmental Damage

Obviously, within a discussion of compensation for environmental damage one should also discuss insurance aspects. This discussion is short since insurance is looked at at a more general level from a law and economics perspective in another chapter in this encyclopaedia. Hence, we shall merely summarize the most important research results related to the application of insurance theory to environmental damage. Insurability issues have generally been discussed, among others, by Faure (1995a), Karten (1997) and Zeckhauser (1996).

15.1 Moral Hazard

First one can note that the general principles underlying any insurance cover must obviously be respected with environmental liability insurance as well. Therefore the devices suggested by, for example, Shavell (1979) must be taken into account. One of these devices consists of still exposing the insured partially to risk which will often be done through for example deductibles or by imposing an upper limit on coverage (the upper limit is therefore not only necessary given the limited capacity of the individual insurer, but also to control moral hazard). In addition the insurer, should monitor the behaviour of his insured as much as possible, adapt the premium accordingly and require specific preventive measures through the policy conditions. Such an optimal control of moral hazard obviously requires information by the insurer (Endres and Schwarze, 1991). This may require a specialization of insurers engaging in insuring the environmental liability risk in order to be able to exclude bad risks or reward good risks and require relevant preventive measures. On the role of insurance to promote sustainability see Stahel (1997). Insurability issues with respect to hazardous waste have been analysed in the contributions to Kunreuther and Gowda (1990).

15.2 Adverse Selection

In the absence of an accurate distinction between good and bad risks, risk pools may become too broad, giving the good risks an incentive to leave the pool thereby creating the famous risk of adverse selection (Akerlof, 1970). This risk of adverse selection led - according to Priest (1987), but criticized by Viscusi (1991) - to an insurance crisis in the US

15.3 Capacity

In addition to moral hazard and adverse selection there is a third condition for insurability which might play an important role when insuring the environmental risk, being simply the capacity of the individual insurer. Since there is often little *ex ante* information on the predictability of the risk, a relatively low probability that the event will happen and a relatively high magnitude of the damage once the risk occurs, the insurer will have to react by, on the one hand, charging a risk premium to account for the unpredictability of the risk (often in the absence of reliable statistics) and, on the other hand, by providing for an adequate reserve to be able to provide cover for the environmental damage once it occurs. Since the magnitude of the damage will often exceed the possibilities of an individual insurer he will use various traditional insurance techniques (co-insurance, re-insurance) to cope with this capacity problem. One other solution in case of environmental liability insurance is pooling of capacity by insurers. In many countries insurers have shared risks in mutual pools on a non-competitive basis to be able to provide coverage also for risks with a relatively high potential magnitude. This is also typically the case for the nuclear risk. One should, however, distinguish the pooling of risks by insurers in so-called insurance pools from the pooling of risks by operators through risk-sharing agreements which we shall discuss below (Section 16).

Hence, in environmental liability insurance the insurer might want to use specific techniques to be able to provide coverage even for relatively large losses.

15.4 Latency

Another problem we have already referred to (Section 14.5) is latency. When legal standards change over time and new standards are applied to 'old' situations (which will sometimes be the case with liability for soil clean-up) insurance problems may arise. If the risk must be considered to be totally unforeseeable the insurer could not charge a premium *ex ante* for the specific risk, nor could he require specific preventive mechanisms or set aside reservations for potential losses. On the other hand, insurers principally always deal with uncertainty, so that the risk that the law may change must not under all circumstances be considered as unforeseeable. A specific risk premium could be charged in addition to the actuarially fair premium to cope with this

uncertainty problem (Kunreuther, Hogarth and Meszaros, 1993).

Since latency problems will often arise in case of environmental liability the insurer may want to protect himself against the risk of being held liable today (maybe even on the basis of a retroactive application of new standards) for risks that originated for example 15 or 20 years ago. One possibility often advocated in the literature now and applied in many insurance policies is to change the period of insurance cover. Instead of providing coverage for the period when the harmful event occurred or when the loss originated, insurers now often change to a system whereby the claim must have been filed during the period of insurance cover (a so-called claims-made system). By using this insurance technique the insurer can exclude the risk of being confronted with claims years after the period of insurance cover. Hence, this 'claims-made policy' allows for an exclusion of the so-called 'long-tail risk' which is typical in case of environmental liability with latency problems (Katzman, 1988; Hankey, 1994; Spier and Haazen, 1996).

15.5 Causal Uncertainty

Another problem that may specifically arise in case of environmental liability insurance is causal uncertainty (also discussed in Section 14.3) if for example a joint and several liability rule is used, this would mean that the insurer would have to cover risks that were not even caused by his insured. This may cause uninsurability, as has been shown by Abraham relating to insurance for superfund clean-ups in the U.S (Abraham, 1988).

15.6 Insurance Principles

There are, moreover, some other specific features of environmental liability insurance, which are discussed in the literature, which make it difficult to apply traditional insurance principles to environmental liability. One of these aspects, often stressed, is that liability insurance traditionally provides for coverage of accidents, meaning a sudden event whereas, as we just indicated - in environmental liability there is often a long time lapse between the emission and the occurrence of the harm. Moreover, many of the pollution cases are not sudden events, but evolve gradually. This causes many technical problems, for example relating to the question when the damage actually occurred. These and other questions relating to the application of insurance principles on environmental liability are extensively discussed in law and economics literature (see for example Bocken, 1992, 1993; Bocken and Ryckbost, 1991; Cousy, 1995).

15.7 Compulsory Insurance

Finally, we should also point to the fact that the question can arise whether liability insurance for environmental damage should be made compulsory. We can be brief concerning this issue here since the law and economics of

compulsory insurance is extensively discussed in Chapter 2400 (see also Faure and Van den Bergh, 1989a; Jost, 1996; Skogh, 1989b). In this respect we should only point out that some legal systems, for example Germany, have imposed a duty to insure on certain operators for environmental harm. The efficiency of such a duty and other aspects are analysed by Endres and Schwarze (1991) and Wagner (1991, 1992, 1996), specifically relating to the German Environmental Liability Act.

16. Other Compensation Mechanisms

Increasingly a lot of attention is paid to other mechanisms that could be used to cover for environmental damage. Some believe that the insurance problems mentioned above are that important that insurance can in the end only play a small role in covering the environmental risk. Especially as far as financing clean up of polluted sites is concerned, many have argued that alternative financial schemes must be investigated other than traditional liability and insurance.

Skogh (1982; 1989a) and Hansson and Skogh (1987) have argued that when the two policy goals of optimal prevention and optimal compensation have to be fulfilled, the policymaker can choose between either liability rules with private insurance on the one hand, or safety regulation and public compensation mechanisms on the other. This literature develops criteria for when public compensation mechanisms, such as compensation funds, could show comparative benefits. Faure and Hartlief (1996) have argued that no matter how a compensation mechanism is organized, the incentives for prevention of damage should always remain untouched. Hence, the costs of harmful behaviour should as far as possible be attributed to the one who caused the harm and a system of risk differentiation should be included in the financing system as well. Therefore, a public compensation mechanism should still provide incentives for prevention by forcing only those who actually contributed to the damage to contribute to the fund, for example.

Obviously, an alternative compensation mechanism for environmental damage could take various forms. One possibility one could think of would be a mutual risk-sharing of operators. In case of very technical risks operators might have better information on the risk than an insurance company or an administrative agency, for example. Hence, the accident risk could be reduced via an optimal mutual monitoring of the operators. There is a large experience with these risk-sharing agreements in the field of compensation for oil pollution. This is provided by the so-called Protection and Indemnity Clubs (P&I Clubs), which are based on a mutual risk sharing between tanker owners (see, for example, Coghlin, 1984). Faure and Skogh (1992) have argued that also a risk-sharing agreement between nuclear power plant operators could lead

to a better monitoring and provide higher amounts of compensation for victims than with traditional insurance. There is some evidence that risk-sharing agreements will indeed be used in the revision of the Paris and Vienna Conventions on Nuclear Liability (Faure, 1995b).

Compensation funds are in some cases also advanced to cover for insolvency of insurance companies. These so-called guarantee funds usually intervene when for some reason traditional insurance fails. In those cases a guarantee fund is usually applied in combination with traditional insurance; the fund then intervenes only for example when for some reason there is no insurance cover (for the basic argument see Finsinger, 1996). The third type of fund is a public compensation mechanism that really takes the place of traditional insurance because the particular risk may be uninsurable. In the environmental context one can think of situations for which no individual injurer can be made liable, for example the degradation of a particular habitat caused by acid rain. Inevitably the question arises how the fund can be financed, taking into account the causes of the particular pollution problem. If it is clear that for example sulphur dioxide emissions caused the particular problem from an economic point of view, one could argue that a tax should be introduced on the polluting activity which can be used to finance the compensation fund. This was basically the idea behind one of the major environmental funds known today, namely the American superfund introduced by CERCLA. The law and economics of the superfund experience has been analysed in a recent book edited by Revesz and Stewart (1995). This book provides a valuable insight into the economics of the superfund system, addressing issues such as the applicable liability regime, the role of insurance industry, clean-up standards and more particularly the transaction costs involved in the current superfund regime.

Other no-fault compensatory alternatives for environmental injuries are discussed by Dewees, Duff and Trebilcock (1996, pp. 328-331). They equally discuss both compensation for oil pollution and nuclear liability, although they rightly stress that the American Price Anderson Act (on nuclear liability) was largely motivated by a desire to allow the development of a nuclear power industry. They show little enthusiasm for an environmental disease compensation fund, arguing that many of the problems of the liability system, for example causal uncertainty, would not be removed by the instalment of a fund. Indeed, the administrative agency handling the fund would have to determine whether an individual disease is caused by the specific pollutant, which might render the administration of such a fund difficult and expensive. In Europe there are some experiments introducing environmental compensation funds on a rather small scale (for an overview see Bocken, 1987, 1988, 1990, 1991).

D. Theory of Regulation and Other Aspects

17. Public Interest Criteria for Regulation

17.1 Criteria for Regulation

After having discussed the economic function of environmental liability we now come to the question under what type of circumstances liability rules or other common law instruments will not suffice to deter environmental pollution, so that a regulatory intervention is necessary. The basic economic arguments in favour of (safety) regulation have been formulated by Wittman (1977), Shavell (1984a, 1984b, 1987a) and by Kolstad, Ulen and Johnson (1990). Several criteria have been developed to indicate when liability rules alone will not provide a sufficient incentive for a firm to take efficient care. In case of the environmental risk most of these criteria point in the direction of *ex ante* regulation: information can be obtained more easily by the regulator, there is an insolvency risk and a serious risk of underdeterrence since no liability suit will be brought if, for example, the damage is widespread. This literature indicates that there is a strong case for controlling environmental harm through regulation, whereby we can refer to the literature mentioned above which discusses the question whether this *ex ante* regulation should take the form of taxes or the command and control approach via emission standards in licenses. In legal practice regulation plays an important role in controlling environmental harm. Similar economic criteria for regulation are advanced in Ogus's recent book on regulation (1994b, pp. 29-46).

17.2 Enforcement

Many studies have addressed the effectiveness of specific environmental regulations. A lot of attention has in this respect been paid to the enforcement of environmental regulation. Shavell already stressed that one of the weaknesses of regulation in comparison with tort law is that whereas in tort law a victim will usually have an incentive to sue if he is injured, the damage is sufficiently large and the injuries can be identified, the effectiveness of environmental regulation will to a large extent be dependent on the possibilities of enforcement. Enforcement issues have been addressed for example by Hawkins (1984), McKean (1980), Richardson, Ogus and Burrows (1982), Russell, Harrington and Vaughan (1986) and Russell (1990). The question what kind of penalties have to be used to deter inefficient emissions has been addressed by Segerson and Tietenberg (1992). They more specifically address the question how an optimal penalty structure can be achieved in case of corporate environmental crime, addressing the question under what kind of circumstances there should be individual or criminal penalties or a combination of both. The effectiveness of criminal liability for environmental offenses has also been addressed in the many publications in this field of Cohen (1987,

1992a, 1992b). He argues that the magnitude of criminal sanctions should be based on harm, thereby criticizing the current American sentencing guidelines which hold that the fine should be based on the illegal gain. Furthermore, Cohen argues, as many other authors do, that criminal sanctions are only one part of the total picture, since civil sanctions and private settlements must be taken into account as well. Deterrence of environmental harm has been investigated as well by Epple and Visscher (1984), developing a model to measure the effectiveness of enforcement efforts. Recently Gren and Kaitala (1997) examined the possible gains for the enforcing agency from disseminating information as its skill on detecting and convicting violators.

17.3 Effectiveness

Finally we can point at literature that generally examined the effectiveness of safety regulation in controlling environmental harm. Dewees (1992a, 1992b) demonstrated that in North America the quality of the environment has improved substantially as a result of regulatory efforts, not so much in response to legal action in tort. This empirical evidence of the success of regulation, compared to tort law, has also been stressed in the recent book by Dewees, Duff and Trebilcock (1996). They hold that the large regulatory effort to improve the environment has been met with considerable success when measured by the reduction of emissions, but that it is more difficult to argue that the environmental regulations of the 1970s in the US equally had a considerable influence on the ambient environmental quality. Moreover, they also stress that while environmental regulation is a determining factor in pollutant emissions and ambient concentrations, other non-regulatory factors such as economic growth and even the weather also influence environmental quality (Dewees, Duff and Trebilcock, 1996, pp. 307-323).

18. Private Interest Theory of Regulation

18.1 Lobby for Barriers to Entry or Lenient Standards

Until now we have assumed that government regulation is always made 'in the public interest', meaning that the government would always make environmental regulation to cure the externality in an optimal way. Reality is, however, often very different. Sometimes regulation is passed if it would not be necessary according to the criteria for regulation of Shavell, discussed above; in other cases there is a proper argument for regulation, but the contents of the regulation is inefficient. This phenomenon, being that regulation is sometimes promulgated not in the public interest, has been examined by scholars of the public choice school. Public choice is analysed in Chapter 0610 of this encyclopaedia, where the basic literature in this respect is discussed. For this

contribution it is interesting to discuss some of the literature that applies public choice and other interest group theories to environmental law.

The starting point of the public choice analysis is that regulation is considered as the product of supply and demand on a political market. On the demand side we find the various interest groups who demand favourable regulation and on the supply side, the wealth-maximizing politicians who wish to favour interest groups which provide them with political support. The product is environmental legislation protecting an interest group in exchange for political support. Thus a wealth transfer (a so-called rent) can be transferred to the interest group protected. This rent-seeking behaviour will be especially successful, according to the literature, if the transaction costs of bringing together individuals to defend a common interest are relatively small for the group and if the information costs incurred by the public at large to find out the rent-seeking are relatively high. These conditions for rent-seeking may often be met in case of environmental regulation. The fact that a transfer to an interest group has taken place will often be disguised by arguing that environmental protection or victim protection is provided by the particular piece of legislation. Transaction costs are often low if only a few firms come together to defend a common interest.

There is a lot of literature providing theoretical support for the rent-seeking argument in case of environmental regulation and empirical evidence as well. The starting point for environmental regulation is often the political will to provide some action for environmental protection. Keenan and Rubin (1988) would argue that this demand for regulation, which is not represented by a well-defined and active particular interest group, may be initiated by a so-called shadow interest group. This is a group that would have members and would come into being if an accident occurred. Potential victims of environmental pollution can thus be seen as members of this latent group. If a shadow interest group ceases to be a shadow group and becomes active, it will have all the characteristics of a normal interest group. Knowing that shadow interest groups have the potential to become an effective lobby, rational politicians will, under certain circumstances, respond to these groups in the same way that they will respond to normal interest groups, even though the shadow groups have not yet been organised.

If under these circumstances legislative intervention seems unavoidable, the theory of regulation suggests that the interest groups involved will accept a general principle of regulation, but may strive to change its scope (Peltzman, 1976). The industrial interest groups to whom the environmental regulation will be applied may realize that regulation may enhance producer wealth while it simultaneously corrects, or at least reduces, an externality problem. This outcome has been stressed by Maloney and McCormick (1982) with respect to environmental quality regulation. They argue that the industry, realizing that environmental regulation is unavoidable, will cooperate in the development of

the regulation and try to change the contents to its advantage. A classic example is the introduction of so-called 'grandfather clauses' which stipulate that the regulation will not be applicable to firms or products which are already in existence. Hence, the regulation can create a new barrier for market entry and so protect the existing industrial practices and products (see also Dewees, 1983a). In other cases, for example as far as standard-setting is concerned, industry may lobby for lenient environmental standards to increase their own profits.

As indicated above, the efforts of industry may go in various directions: sometimes regulation will be used by using grandfather clauses to limit market entry (Maloney and McCormick, 1982); in other cases there will be lobbying for more lenient environmental standards. With respect to the first type of lobbying we can refer also to the function of licenses, which are considered a central instrument in environmental policy. Moore (1961) pointed at the anti-competitive effects of licensing (see also on the use of standards to seek competitive advantages Hahn, 1990b; Huber, 1983; Ogus, 1994a).

Evidence of rent-seeking behaviour in environmental regulation in the US was recently reported by Adler (1996) and similar stories can be found in Europe as well (Faure and Van den Bergh, 1990).

The lobby for lenient standards may take place with the legislator. But since legislators usually give standard-setting power to administrative agencies, this type of lobbying, for example to get lenient emission standards for an individual firm, will usually take place with the administrative agency. The behaviour of bureaucracies in response to this capturing by industry is analysed in different papers, for example by Downing (1981). Rent-seeking will obviously not only take place as far as the standard-setting process is concerned, but can also play a role in case of zoning (Ault and Ekelund, 1988; Fischel 1980, 1985), which is addressed in more detail in Chapter 2200.

18.2 Influence of Private Interest on Instrument Choice

The influence of private interest in environmental law has been addressed specifically in the literature with respect to the issue of instrument choice. In Part C we indicated the variety of instruments that can be used to control environmental pollution, indicating that the literature suggests under what kind of circumstances a particular type of policy instrument would be optimal. In practice these 'economic prescriptions' (Hahn, 1989a) are not always followed. One reason why emission taxes are seldom used, for example in the US, and policy still relies to a large extent on the command and control approach is that firms prefer emission standards to taxes, because standards serve as barriers to entry to new firms, thus raising the profits of existing firms. Charges on, the other hand do not preclude entry by new firms and represent an additional cost to the existing firms on the market (Buchanan and Tullock, 1975 and see the comments by Coelho, 1976 and Yohe, 1976). This basic point made by

Buchanan and Tullock has been extended by other scholars examining the implication of rent seeking for pollution taxation (Lee, 1985; Brooks and Heijdra, 1987). The influence of lobbying on instrument choice has also been analysed in the many papers by Hahn (Hahn, 1989a; Hahn and Noll, 1983; Körber, 1995) and by De Grauwe (1995). Hahn points out that the policy instruments are almost never used in the way that is suggested by economic theory. Emission charges are, for example, used as a revenue-raising device with few direct effects on polluters and many marketable permit approaches are not really designed to create markets. Through grandfathering the rights of existing firms are often protected. In addition, even in cases where the economic prescriptions (marketable pollution rights) were followed, there is some evidence that emissions trading was used as a loophole by which industry could forestall compliance (Hahn and Hester, 1989). Hahn also argues that the varying interest group attitudes in, for example, the US and Europe may account for the fact that European countries tend to rely more on the use of fees, whereas marketable permits have been introduced at a relatively important scale in the US (Hahn, 1989a, p. 111). Hence, the selection of an appropriate mix of policy instruments will to a large extent be determined by the way political choices are actually made in different countries.

18.3 The Choice for the Level of Government

The influence of interest groups will not only play a role as far as the contents of regulation is concerned, but also when the level of government where action will be taken is determined. Noam has argued that interest groups will obviously choose the level of government where their influence can be largest. In the context of the European Union Faure and Lefevre argued that this may explain why some industries will lobby in favour of environmental regulation at the European level. For new areas (where no national legislation exists) industrial lobby groups may encounter less countervailing power than at the local level where the environmental problems occur and NGOs may oppose lenient standards. Once standards are set at the central level in Brussels, Member States will have to comply. On the other hand, the industry of Member States which already have relatively stringent environmental standards may have an incentive to lobby at the central level to make these stringent environmental standards compulsory unionwide to force (southern European) competitors to comply with these stringent standards as well and thus to create barriers to entry (Faure and Lefevre, 1995). This may explain why a lot of environmental regulations will emerge from Brussels also in cases where economic theory would predict that the problem may better be dealt with at the decentralized level (see Part F).

18.4 Liability Law and Rent-Seeking

Finally, one should not forget that rent-seeking can also take place in environmental liability law. Industry may lobby in favour of a financial cap on

liability thus transferring a rent from potential victims. Caps can be found for example in conventions on marine oil pollution and nuclear liability. The ideal conditions for efficient rent-seeking will often be met: transaction costs for the nuclear industry, for example, are low and the information costs for the public are high since the caps are often combined with other legal instruments which are supposedly aiming at 'victim protection' such as strict liability and compulsory insurance (see Faure and Van den Bergh, 1990).

18.5 Importance

The interest group theory is important both for theoretical research and at the policy level. Theoretically it is important to stress that these theories have demonstrated that the traditional argument that regulation is necessary if the market fails to internalize externalities may not necessarily be true if the regulation provides results that are inefficient as a result of rent-seeking compared with the market solution that would have emerged. Second, most authors stress that it would be too one-sided to argue that environmental laws only serve the private interest. Even if there will always be strong incentives for rent-seeking, many environmental statutes are still enacted in a struggle to protect the public interest (Adler, 1996). Third, in some cases the interests of industry and environmentalist coincide; hence, lobbying will not always result in industry opposing environmental regulation. Fourth, theoretically, a combination of public interest and private interest approach is highly useful to provide an understanding of how environmental regulations work. If the environmental policy instruments actually used do not correspond with the predictions of (public interest) economic theory, it might be helpful to look at the possible influence of private interest groups which might explain the existence of inefficient environmental regulation. Fifth, the fact that environmental regulation too is susceptible to rent-seeking which might for example lead to too lenient standards, may be an argument for combining regulatory standards with other policy instruments such as liability rules, which may be less susceptible to the influence of private interest.

19. Liability and Regulation Combined

19.1 Necessity of the Combination

In Section 17 we stated that according to Shavell's criteria there is a strong argument to control the environmental risk through *ex ante* regulation (or taxes). However, in individual cases there can still be damage to the environment. Then again liability under tort comes into the picture and the question has been addressed in the literature how regulation influences the liability system and vice versa. These complementarities between tort law and regulation have more particularly been addressed by Rose-Ackerman (1992a,

1992b, 1996), Faure and Ruegg (1994) and Kolstad, Ulen and Johnson (1990). Rose-Ackerman also compared US and European experiences in using regulation versus tort law in environmental policy (1995a, 1995b). The first point which is often stressed, is that the fact that there are many arguments in favour of *ex ante* regulation of the environment does not mean that the tort system should not be used any longer for its deterring and compensating functions. One reason to still rely on the tort system is that the effectiveness of (environmental) regulation is dependent upon enforcement, which may be weak. In addition the influence of lobby groups on regulation, just discussed, can to some extent be overcome by combining safety regulation and liability rules. Moreover, safety regulation, for example emission standards in licenses, can be outdated fast, which equally merits a combination with tort rules.

19.2 Violation of Regulation and Liability

The question then arises whether a violation of a regulatory standard should automatically be considered a fault under tort law and thus lead to liability. Shavell argues that this should not necessarily be the case, so as to avoid some parties who pose lower risks taking wasteful precautions (Shavell, 1984a, pp. 365-366). However, in many legal systems, a breach of a regulatory duty is often considered a fault. This can be understood since the regulation will pass on information to both the parties and to the judge on the efficient standard of care. Thus the statutory standards can be applied to define negligence (Rose-Ackerman, 1992a).

19.3 Compliance with Regulation and Liability

A second question is whether following the conditions of regulation, often laid down in a license, excludes liability. This point of view is usually rejected in most legal systems (Faure and Ruegg, 1984, pp. 55-56). The economic rationale behind this rule is that if compliance with a regulatory standard were to release the operator from liability, there would be no incentive to invest more in care than the regulation asks for, even if additional care could still reduce the expected accident costs beneficially (Shavell, 1984a, p. 365). A second reason is that exposure to liability even in case of compliance with regulatory standards may be an adequate remedy when too lenient standards are set as a result of lobbying. Finally tort law can also be seen as a 'stop gap' for situations not dealt with by statute (Rose-Ackerman, 1992a, p.123). A problem with this point of view is, however, that it may destroy the uniformity a standard is supposed to bring when judges are allowed in all cases to 'second guess' agency decisions (see Rose-Ackerman, 1992a, p.124).

The issue whether *ex post* liability and *ex ante* safety regulation are substitutes or complements has also been addressed by Kolstad, Ulen and

Johnson (1990). They show that where there is uncertainty, there are inefficiencies associated with the exclusive use of negligence liability and that *ex ante* regulation can correct these inefficiencies. In that case they argue a joint use of *ex ante* and *ex post* regulation will enhance efficiency.

19.4 Liability and incentive-based instruments

Finally it should be mentioned that in the literature some attention has been given to the problem of combining tort recovery and effluent fees or tradeable rights. Rose-Ackerman has argued that incentive schemes require a fundamental rethinking of the relationship between tort law and statutory law. She has argued that incentive-based regulatory statutes should preempt tort actions: if fee schedules have been set to reflect the social costs, tort actions would be redundant or even counterproductive (see, for example, Rose-Ackerman, 1992a, p.128).

E. Environmental Federalism

20. Criteria for (De)centralization

So far we have discussed the goals of environmental policy assuming a harmonized legal system which would be applicable to all kind of different situations. It is, however, obvious that environmental problems may vary highly between communities. This brings about the highly controversial question at what level of government environmental problems should be regulated. This issue receives increasing attention in the literature, both in Europe and in the US. The central question always is whether environmental regulation should be promulgated at central (European or federal) level or at a more decentralized level. A more balanced question is what kind of environmental regulations (or standards) should be set at the central and at the decentralized level. This issue has generally been addressed in the economics of federalism.

The starting point of the analysis usually is the theory of Tiebout (1956) about the optimal provision of local public goods. Tiebout argues that when people with the same preferences cluster together in communities, competition between local authorities will, under certain restrictive conditions, lead to allocative efficiency. Well-informed citizens will move to the community that provides services that are best adapted to their personal preferences. Hence, there would be competition between legal orders and citizens would move (the so-called voting with the feet) to the community that provides legislation that corresponds best with their preferences. This basic idea has been further developed with application to fiscal decisions and environmental choices by Oates and Schwab (1988). Recently Van den Bergh (1994a, 1994b) has built

on the Tiebout model to provide criteria for centralization/decentralization within the European Union. Van den Bergh argues that from an economic point of view decentralization should be the starting point, since competition between legislators will promote efficiency. However, there are certain conditions under which Tiebout competition will not work and which can, therefore, constitute arguments in favour of centralization. One argument is the transboundary character of externalities: this may be an economics of scale argument to shift powers to a higher legal order that has competence to deal with the externality over a larger territory. A second argument is the risk that a 'race for the bottom' between countries would emerge to attract foreign investments. This race for the bottom would cause prisoners' dilemmas whereby countries would fail to enact or enforce efficient legislation.

21. Environmental Issues

These insights can also be applied at environmental problems, as was the case, for example, in the just mentioned paper by Oates and Schwab (1988). Both general arguments in favour of centralization could play a role with environmental problems. It can be argued that these are certainly often transboundary. The prisoner's dilemma argument could be valid as well if there were empirical evidence that differences in marketing conditions may lead to dislocation of firms to the location with the lowest standards (the so-called race for the bottom argument). Whether this argument is valid depends on empirical findings which we shall discuss below. Van den Bergh's arguments comply with the findings in another paper by Oates and Schwab (1988) who equally argue that as long as the effects of pollutants are confined within the borders of the relevant jurisdictions, local authorities will make socially optimal decisions on levels of environmental quality. Hence they provide an argument for decentralized environmental policy and argue that competition among jurisdictions for economic activity need not be 'destructive'. A similar argument against the race to the bottom rationale for central environmental regulation is made by Revesz (1992). He argues that this race to the bottom argument encounters no support in existing models of interjurisdictional competition. In addition, Revesz stresses that central-standard-setting would not be an effective response to this race to the bottom problem since local communities concerned would have other means to attract industry if they wish (relax regulatory controls in other areas).

22. Subsidiarity and the 'Race for the Bottom' Rationale

If we now turn to the actual division of competences, for example in Europe, we should first mention that the question whether action should be taken on community or national level is now guided by the so-called subsidiarity principle. On the basis of article 3B(2) of the EC Treaty, the community shall take action 'only if and insofar as the objectives of the proposed action can not be sufficiently achieved by the Member States and can, therefore, by reason or the scale of effects of the proposed action, be better achieved by the community'. If we apply the economic criteria in favour of centralization to the areas in which the European Community legislated, one can certainly argue that many of the problems regulated through directives, for example, deal with transboundary problems. In many other cases the race to the bottom argument is disguised by mentioning that the creation of equal conditions of competition is necessary for the functioning of the common market. However, the empirical evidence to uphold this rationale is rather weak. Repetto argues that pollution control costs are only a minor fraction of the total sales of manufacturing industries (Repetto, 1985). Moreover, recently Jaffe et al. (1995) have argued that empirical evidence shows that the effects of environmental regulations are 'either small, statistically insignificant or not robust to tests of model specification'. They argue that the stringency of environmental regulations might have some effect on new firms in their decision to locate for the first time, but that this will not induce existing firms to relocate. They equally argue that other criteria such as tax level, public services and the unionisation of labour force have a much more significant impact of the location decision than environmental regulation. Recently this empirical evidence has been somewhat contradicted by Xing and Kolstad (1995), who argue that the laxity of environmental regulations in a host country is a significant determinant of foreign direct investment from the US chemical industry. The more lax the regulations, the more likely the country is to attract foreign investment, so Xing and Kolstad argue. Although this somewhat weakens the evidence presented by Jaffe et al. as far as the location of new firms outside the US is concerned, it does not contradict their finding that existing firms will not relocate because of the stringency of environmental regulations. This material, therefore, substantially weakens the prisoner's dilemma argument both for European Community and for US federal legislation in the field of environmental law. Even if differences between local communities would exist as far as the stringency of environmental law is concerned, this will generally not lead companies to relocate to 'pollution havens'. Nevertheless, many European Directives deal with, for example, drinking water or bathing water, problems which are typically not transboundary and for which the European competence is therefore hard to fit in the economic framework (see Faure, Lefevre and Van den Bergh, 1996a; Faure and Lefevre, 1996).

As far as the federalisation of environmental law in the US is concerned, we can point at an early work of Peltzman and Tideman (1972) and at a historical overview provided by Elliott, Ackerman and Millian (1985) and at the work of Revesz who in addition to his already mentioned 1992 paper in which he criticizes the race to the bottom rationale for federal environmental regulation, recently also criticizes the various approaches that federal environmental laws have taken in controlling interstate externalities (Revesz, 1996).

23. Environmental Standard Setting

At the European level there is, however, another reason for environmental action at central level. This has to do with guaranteeing all European citizens a similar environmental quality. This is sometimes referred to as the protection of the 'European environmental and cultural heritage and human health'. In a Tiebout framework of competition between legal orders, local communities would be free to choose the environmental quality that corresponds with their preferences. This is precisely the reason why in the US context one can increasingly hear pleas in favour of standard-setting by the states instead of by the federal environmental protection agency (see Schoenbrod, 1996), whereas in Europe one wishes to guarantee citizens a minimal environmental quality. But even if one accepts that a basic environmental quality should be guaranteed (contrary to the economic reasoning) to all of the citizens, irrespective of their individual preferences, this should not be realized through a harmonization of emission standards, as was done at the European level so far. This basic environmental quality can be guaranteed by harmonizing quality (target) standards. These quality standards define how much of each pollutant can be present in a certain environmental component. But the theory of optimal specificity of legal rules (Ehrlich and Posner, 1974; Ogus, 1994a) has taught that the costs to reach a certain level of environmental protection may well vary with location-specific circumstances (Kolstad, 1987; Faure and Lefevre, 1995). Hence, the same environmental quality can be reached in Europe through differentiated emission standards aiming at an equal environmental quality Europe-wide (Faure and Lefevre, 1996).

F. Specific Environmental Problems

24. The Nuclear Risk

24.1 Safety Regulation

There are two types of environmental risks that deserve a short separate

treatment since there is some literature dealing specifically with nuclear risks and oil pollution. Obviously, most of the problems addressed so far appear with these two risks as well, so we shall simply report on some of the literature addressing specific issues concerning these risks.

As far as the nuclear risk is concerned, Nichols and Wildavsky (1987), Feinstein (1989) and Paté-Cornell (1987) stress the specific character of the nuclear risk, being the low probability of an accident and the difficulties of probabilistic risk assessment in quantifying risk at nuclear power plants. Feinstein examines the safety records of US nuclear power plants and found a sharp increase in detection of violations following the Three Mile Island accident.

24.2 Liability and Insurance

Special attention has equally been given to nuclear liability and the insurance of the nuclear risk. Taking into account the economic test for strict liability, nuclear accidents pose a strong case in favour of strict liability, since these accidents are typically unilateral (Faure, 1995b). Most international conventions on nuclear liability also adopted a strict liability rule. However, in many legal systems the compensation due to victims is also statutorily limited to relatively low amounts. Here we can refer to the discussion of financial caps above: these are largely inefficient, lead to underdeterrence and undercompensation of victims (Trebilcock and Winter, 1997).

As far as nuclear insurance is concerned, it should be mentioned that in most legal systems, insurance is provided by national nuclear pools, which have brought resources together on a non-competitive basis and provide relatively low amounts for third-party insurance. This liability-insurance scheme for the nuclear risk can to a large extent be explained as the result of lobbying by the nuclear industry (Faure and Van den Bergh, 1990). The conventions on nuclear liability which were drafted in the 1960s had as their main goal to guarantee that nuclear power could further develop and that the nuclear industry would be protected against high claims. Hence, strict liability was combined with relatively low caps, also to make the nuclear risk insurable. An alternative compensation mechanism would be the pooling of risks by operators, based on a risk-sharing agreement whereby a mutual monitoring between plant operators would guarantee prevention and higher amounts of compensation could be made available (Faure and Skogh, 1992).

24.3 Causal Uncertainty

Finally, it should also be mentioned that in case of the nuclear risk many problems of causal uncertainty will arise. Usually a probability of causation formula is used to investigate the likelihood that a certain disease (for example cancer) was caused by a certain exposure to radiation (Bond, 1981; Ketchum, 1985). However, in practice it is often very difficult to establish this probability of causation: data on these probabilities in individual cases are certainly not conclusive (Estep, 1960; Meddler and Moselly, 1985; Van Mieghem, 1988).

25. Marine Oil Pollution

Marine oil pollution is also an issue which received attention in the literature, even before environmental problems were analysed at a general level. Economists have always been interested in the question how accidental or voluntary marine oil pollution by tankers could be prevented optimally either by investments in the safety of the tankers (in case of accidental pollution) or by increasing detection (in case of voluntary discharge) (see, for example, Burrows, Rowley and Owen, 1974). The problem of detection of oil spills has been modelled by Epple and Visscher (1984). They show how vessel size, the price of oil, the enforcement of pollution control regulations and the risk associated with variants in spill size affect the oil transporters' decisions concerning expenditures on measures for spill prevention. They provide empirical data to support their theoretical analysis. Cohen (1987) has followed up on their work by providing an optimal enforcement strategy to prevent oil spills. We can also point at a paper by Dunford (1992), addressing the natural resource damages from oil spills, addressing the question under what kind of conditions there can be liability under the US Oil Pollution Act for natural resource damages. The recovery for economic loss following the Exxon Valdez oil spill has been examined by Goldberg (1994).

One important weakness in the enforcement of marine oil pollution is the fact that the so-called Protection and Indemnity clubs provide full insurance for the fines which are imposed (Lomas, 1989). However, Faure and Heine (1991) have argued that it is not the insurance itself which poses the problem, but the low probability of detection, which causes a low expected fine.

Furthermore, we can point at the fact that the liability regime for oil pollution is governed by international conventions that have a similar legal structure as the conventions on nuclear liability: strict liability with financial caps. Insurance is provided through the Protection and Indemnity clubs, mutual insurance companies of the ship owning companies, which is typically different than in the nuclear liability sphere (see Bongaerts and De Bièvre, 1987). These oil pools are as such not inefficient and costly government regulations would

not be able to improve efficiency to a large degree (see Libecab and Wiggins, 1984; Ault and Ekelund, 1988, p. 75). Another major difference with the nuclear liability regime is that in case of maritime oil pollution compensation is provided not only through these P&I clubs, which act as insurance companies, but also through an oil pollution fund, financed by taxes on crude oil. In this case there is hence a combined financing by the oil-producing industry and the ship owners (see on liability for marine oil pollution the contributions in De la Rue, 1993).

G. Concluding Remarks - Points for Further Research

This overview of the literature on environmental law and economics was unfortunately nothing more than a selection. So much has been published in this area that it would be impossible to discuss every paper published. The reader should be aware of the fact that some topics have not been discussed at all. This is, for instance, the case for the important area of international environmental law. A lot of economic research, especially in the area of international environmental economics, has focussed on issues such as the greenhouse effects, CO₂ emissions, and so on. However, more research can be done in this area, for example concerning the use of the various instruments to control transboundary pollution. In particular the effectiveness of international environmental agreements merit further research from both a law and economics and a public choice perspective.

The brief overview of literature provided in this contribution has shown that many aspects of the environmental problem have now been analysed from a law and economics perspective. It is, however, remarkable that most of the environmental economics research has for a long time particularly focussed on tradeable permits and environmental taxes, paying less attention to other instruments such as, for example, liability rules and insurance, whereas liability played a crucial role in the traditional law and economics literature on externalities. One point for further research is the possibility of an integration of the various instruments to control environmental pollution. It merits careful analysis under what kind of specific circumstances various standards, taxes or liability rules are best suited to control environmental pollution and under what kind of circumstances a combined use of these instruments might be optimal. Furthermore, increasingly public choice analysis should be taken into account in the analysis of environmental regulation. Many of the inefficiencies discovered in environmental regulation might be due to the influence of interest groups. In addition, attention should be paid to the institutional conditions under which interest groups might be less successful and environmental regulation can be expected to be more in the public interest. Finally, we did not pay attention at all to other than legal instruments which may play an

important role in controlling the environmental risk. In this respect we think especially of, for example, eco-audits, environmental management systems and voluntary agreements. The efficiency and effectiveness of these instruments equally merit a careful analysis from a law and economics perspective.

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