5 Environmental regulation

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1. INTRODUCTION

The goal of this chapter on environmental regulation is to provide some insight into the law and economics literature dealing with 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 volumes of the Encyclopedia. This is more particularly the case for environmental liability which is dealt with in the volume on tort law and economics (Faure, 2009a) and for environmental crime which can be found in the volume on criminal law (Faure, 2009b). This means that within the framework of this volume, which focuses on regulation, I will merely focus on the law and economics literature specifically dealing with questions concerning the regulation of environmental pollution. Environmental liability and related compensation issues, such as insurance or compensation mechanisms, will therefore not be discussed within this chapter. Since the volume on criminal law contains a detailed chapter on environmental crime which also discusses aspects of monitoring and enforcement, this also means that within this chapter enforcement issues will not be dealt with at all. For those aspects the reader is referred to the chapters in the other volumes of the Encyclopedia.

A second reason why it might be difficult to provide an overview of the 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 that does not address pollution from an economic point of view and, on the other hand, literature on environmental economics, which studies the effects of economic instruments and implementation by firms and households. Some of this literature on environmental economics is clearly of interest to environmental law and economics in as far as the legal instruments to implement envi-

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ronmental policy are studied. However, in this literature, the various legal instruments to control environmental pollution are usually not the central focus of research questions. I 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 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, liability rules and traditional command-and-control mechanisms, such as emission standards for example are also economic instruments in the sense that they give actors an incentive to comply with certain policy goals. In addition, so-called economic instruments are legal in the sense that a system of ecological taxation or of marketable pollution rights needs a legal framework, for example, to determine 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 ‘environmental regulation’, the topic of this chapter. Economists may consider environmental regulation to be all government intervention with regard to the protection of the natural environment. 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 to be different from direct regulation (see also Shavell, 1984a). For the purposes of this contribution, however, as I made clear above, liability rules and other common law instruments are not classified under ‘environmental regulation’ and thus are not discussed in any detail in this chapter.

Furthermore, those interested in an overview of literature with respect to environmental economics are referred to the survey by Cropper and Oates (1992) and to Kolstad (2000). As far as books on environmental law and economics are concerned, I would suggest, for example, referring to Ackerman et al. (1974), Boyer, Hiriart and Martimort (2006), Braden, Folmer and Ulen (1996), Eide and Van den Bergh (1996), Faure and Skogh (2003), Heyes (2001), Revesz, Sands and Stewart (2000) and Swanson (2002).

In this contribution I will try to focus on the main literature, without attempting to be comprehensive. This chapter builds on to the chapter published previously in the 2000 edition of the Encyclopedia which dealt with environmental regulation (Faure, 2000). The main difference with the 2000 edition of the Encyclopedia is that of course account is taken of evolutions in the literature since that date and that, as explained above, environmental liability and environmental crime (as well as related issues such as insurance and compliance strategies) are excluded. At the end of this contribution a bibliography is provided, as well as a list of further readings.

The remainder of this contribution to this volume is structured as follows. After this introduction, I will sketch out how the basic literature on externalities is applied to the pollution problem (2); I will then turn to the importance of cost-benefit analysis in the environmental standard setting (3). In Section 4, the various instruments for controlling environmental pollution will be described. Environmental safety regulation will be addressed in Section 5 and Section 6 will be devoted to problems of environmental federalism. Special attention will be given to problems of the regulation of (environmental) risks under uncertainty and the relevance of the precautionary principle in that respect (7). Given its recent relevance in both policy and academic literature, Section 8 will specifically deal with the law and economics of climate change and more particularly the instrument of emissions trading. A few concluding remarks and points for further research will be addressed in Section 9.1

2. POLLUTION AS AN EXTERNALITY

2.1 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

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1 The specific issues of nuclear liability and marine oil pollution which were separately dealt with in the 2000 version of the Encyclopedia are now dealt with in the chapter on environmental liability in the volume on tort law and economics (Faure, 2009a).
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 simply deals with two fundamental questions, namely:

- What is the optimal level of emissions (which will be addressed in Section 3)?
- 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 earlier work by Pigou (1951), it is usually referred to as a Pigovian tax. By setting the marginal tax rate equal to the marginal costs caused by the harmful activity, the factory would receive 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 content 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 by 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 harm of 200 to each of three victims living in the 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, then 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 content of the legal rule is. 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 took place.

Obviously, the efficient outcome may not occur if one of the parties
behaves strategically or if the zero transaction cost assumption is 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 are fulfilled.

The 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, I can refer to Baumol and Oates (1979), Frey (1992); Oates (1983) and to Schultze and D’Arge (1974). The importance of Coasean bargaining for resolving environmental disputes through alternative dispute resolution is also stressed by Rhoads and Shogren (2001) with further references.

A literature overview concerning the Coase theorem is presented by Mishan (1971a). A drawback of the Coase theorem, especially insofar 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, cases involve multiple victims so that transaction costs would be prohibitive. These drawbacks lead to scepticism concerning the importance of the Coase theorem for environmental problems on the part of, for example, Mishan (1971b) and Kapp (1970). In cases where transaction costs are indeed prohibitive, the Coasean negotiations will not take place and some intervention by the legal system will then remain necessary to reach an internalization of the externality.

2.2 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 for both actors to 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. It is 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 the incremental harm they cause and victims must not be compensated for excessive harm they could have avoided at a lesser cost (Dewees, Duff and Trebilcock, 1996, p. 267). Landes and Posner hold that courts therefore 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. The law and economics of nuisance law is also discussed by Epstein (1979) and by Merrill (1985).

2.3 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 is located in a relatively empty area and is afterwards confronted by neighbours who ‘came to the nuisance’ and then claim compensation or even the relocation of the factory. From an ex ante perspective, these kinds of problems should not emerge since decisions regarding siting of firms could efficiently be made by looking at the optimal area that is suited to 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) and of Fischel (1980 and 1985). 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 addressed as to who should pay for the relocation costs. Again foreseeability may be an important criterion in that respect if, for example, many citizens knowingly start to build houses close to a factory. Even if relocation costs for the firm would be lowest (and the firm 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).
3. COST-BENEFIT ANALYSIS AND ENVIRONMENTAL STANDARD SETTING

3.1 Importance of Environmental Policy

Since I 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 by 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 imposing 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 the protection of the environment. Baumol and Oates propose a predetermined set of standards for environmental quality and then propose the imposition of unit taxes to achieve these standards. The appeal of their approach lies in its 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 damage. In addition, they claim that the selection of standards is quite similar to the approach 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, 1983a and 1983b; Tybout, 1972), which 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) will need to be set.

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 kinds 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 of the use of cost-benefit analysis from a legal perspective (see, for example, Sagoff, 1981, 1988; Hrezo and Hrezo, 1984; Farber, 1989). A powerful plea to use benefit-cost analysis was also made by Kenneth Arrow and other well-known environmental economists (Arrow et al., 1996).

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 benefits and 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 those 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 is calculated. In simple terms: ‘if society is to make the most of its scarce 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).

Since the 1950s, public policies have also been advocated in public finance to control externalities on a marginal cost equalling marginal benefit basis. For the literature on policy analysis see, for example, Friedman (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 environmentally efficient technique, that is the technique for which the marginal costs equal the marginal benefits gained through 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 are higher than the additional benefits from a reduction in environmental damage. With such a balancing process, an optimal environmental quality can be determined and optimal environmental techniques can be chosen.

Obviously, this brief sketch of the importance of cost-benefit analysis for environmental policy cannot provide an in-depth 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 weigh-
ing 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 criticism of 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, the 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 (see on these issues Zerbe, 2002).

An important part of the remainder of this contribution will be devoted to the question of how the law can give incentives to adopt an environmental policy (at government and 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, or cost-effectiveness analyses, are referred to at the policy level. In the work of Sunstein (1993, 1994, 1995, 1996b) and Ogus (1995, 1997), it is claimed that policy-makers 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 clean-ups justify the costs, a question addressed by Gupta, Van Houtven and Cropper (1995). Other studies examine ex post the costs of compliance with environmental regulation, for example, those resulting from the limitation on the use of chlorofluorocarbon (CFC) as a result of the Montreal Protocol in 1987 (Hammitt, 2000).

Finally, I can point to 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, with 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 explicit application of the economic model. The BATNEEC notion (or variations 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 Lefevere, 1996). There is, however, substantial criticism of a standard which is based on the best available technology (BAT) where the regulator re-optimizes environmental regulation in response to new technologies. Bansal and Gangopadhyay showed that cleaner technologies are not adopted if the regulator announces a BAT-based policy (Bansal and Gangopadhyay 2005). If the regulator on the other hand announces a regulation and sticks to it irrespective of the firm’s adopted technology, this so-called commitment policy leads not only to positive investment in research and development, but is also welfare improving.

The use of cost-benefit and cost-effectiveness analyses is often advocated by economists in order to choose those policies which minimize 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. Cost-effectiveness analysis, on the other hand, allows us to identify how, given a certain policy goal (which may not necessarily be efficient), that particular goal can be reached at the lowest possible cost (and is in that sense cost-effective).

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.

### 3.2 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 above-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 means of the perceived monetary changes they have caused in the markets for the affected 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, see 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 Bohn (1971) and for a comparison of both methods of analysis, see Pommerehne (1988). There is a lot of discussion about contingent valuation in the US since it is being used under some environmental laws (for a critical analysis, see 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).

A general survey of methods of valuing environmental damage can also be found in the work of Kapp and Smith (1992), Johansson (1990) and Pearce (1976a, 1976b). 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). This problem of valuation of the rights of future generations is important also in general for cost-benefit analysis since assigning potential benefits to future generations could lead to costly measures today. Revesz (1999) argues that when harms may result in environmental contamination which may affect future generations, discounting is ethically unjustified since it would lead to privileging the interests of current generations. In addition, Revesz argues that upward adjustments of the value of life need to be undertaken to account for the involuntary nature of environmental carcinogens, as well as for the income level of victims. By not performing these adjustments, Revesz claims that the regulatory process risks undervaluing human life. 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. A debated issue is whether moral sentiments, for example, concerning the value of certain ecological assets, should also be taken into account. This again comes down to the question of if and how a market value can be attributed to non-commercial goods, whereby it is adjusted to use a willingness to accept (WTA) measure rather than the willingness to pay (WTP) criterion (see on these issues more particularly Zerbe, 2002). This difference between WTP and WTA has been explored both theoretically (e.g. by Sugden, 1999a and Shogren et al., 1994) and empirically (e.g. by Guria et al., 2005). WTP studies are generally used to attach monetary values to estimate effects in the area of health and safety, for example to estimate the value of health benefits from reducing air pollution (see, for example, Krupnick et al., 2002). Empirical studies have, however, established large disparities between WTA and WTP. A survey in New Zealand showed, for example, that people’s willingness to pay to reduce road risks may be
different from their willingness to accept compensation for an increase in risk (Guria et al., 2005).

3.3 Environmental Standard Setting

3.3.1 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 (for example, 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 ecologically optimal way, or it could simply refer to specific chemical parameters with which, for example, the water in a creek should comply. As I have explained above, economists have traditionally argued that the law should limit itself to setting these targets, in such a way that the instruments used 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 licences. In the environmental area, they will often take the form of emission standards, prescribing the particular quality and quantity of 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, economists often refer to this approach as the ‘command-and-control’ approach. In order to avoid confusion concerning the notion of standards I shall, following the work of Richardson, Ogus and Burrows (1982), distinguish between three types of standards: target standards, emission standards and production standards. The first, target standards, are often referred to as ambient quality standards. They specify the environmental quality as such, namely 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 standards may not entirely solve the information problem. If the harm is not closely connected with 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 addressed to the standard-setting agency generally in the first instance.

3.3.2 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 licences) 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 must 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. 209–11; Stewart, 1981).

In legal practice, one traditionally finds mostly emission standards (the traditional command-and-control approach). They have been criticized from an environmental point of view, since by merely focusing on the 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 expected to be no new entries. This shows that emission standards are therefore momentary static instruments. Overall pollution can no longer be controlled by emission standards as soon as the market situation changes. Moreover, emission standards as such give few 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 has therefore changed to an increasing use of target standards, but in many countries target (or ambient quality) standards have not replaced emission standards. In fact, ideally the optimal environmental quality is first 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 licences), but could also be implemented in emission taxes or take the form of the due care standard in a liability case.

3.4 Standard Setting and Cost-Benefit Analysis

The question arises how the cost-benefit analysis discussed above fits into the division between target and emission standards. Cost-benefit analysis will first of all play a role when environmental targets are determined, as has been indicated above. But cost-benefit analysis will also play a role at this second stage of defining emission standards. 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 the 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 between 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 licence).

Obviously, a large body of literature has addressed the efficiency of various emission standards, especially comparing the traditional command-and-control approach with more incentive-based systems to achieve a given 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 overdeterrence results in other compensating benefits. This outcome is particularly true if economic analysis plays a significant 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.

3.5 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 developments in environmental law. I have 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 to cost-benefit analysis. In international documents, such as the RIO Declaration, Agenda 21 and the EC Treaty as 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 policy orientations rather 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 article 174 (2) of the EC Treaty. Taken literally, this 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, examined whether this principle implies that liability should be extended if the polluter cannot pay.

4. INSTRUMENTS TO CONTROL ENVIRONMENTAL POLLUTION

4.1 ‘Economic’ versus ‘Legal’ Instruments

After having discussed how the optimal amount of pollution can be determined from an economic point of view, I shall now turn to the question of what kinds of legal instruments can be used to reach the goals set. In this part of the chapter, a general overview of various possible instruments will be provided and some attention will be given to environmental taxes and tradable permits. A general account of this market for eco-system control is provided by Johnston (2001–02). A subsequent section will specifically address the role of environmental regulation (Section 5). 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 refuse to invest in abatement techniques would cause higher pollution and would 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 advocates 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 a 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 et al., 1989; Ackerman and Stewart, 1988; Stewart, 1988). However, I have already mentioned above that there is some literature that sheds doubt with respect to this assumption. Oates (1990, 1996b) warns that a sharp distinction between the two approaches might be misleading. Command-and-control approaches also include a wide variety of measures, where some are quite crude, but other measures that have taken cost-effectiveness into account can produce results as efficient as economic incentives.

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), I 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 with ‘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 these goals are (more or less) left up to those 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 achieve environmental policy goals and which are discussed in the literature and actually in practice as well. An excellent overview of the policy instruments for environmental control and their interdependency is provided by Gunningham and Grabosky (1998).
4.2 Common Law Remedies

Starting from the assumption that the Coasean 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 first point to the importance of property rights in providing protection against environmental pollution. Traditional common law, as well as civil law, views most conflicts, for example where a factory emits smoke causing harm to neighbours, as an infringement of 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 the 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 at issue, 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 for efficient behaviour to the actors in a potential accident setting. Even though I do not discuss environmental liability in any detail within this chapter, it clearly appears from the literature that 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). Liability rules can thus give incentives to introduce efficient abatement technology. However, in an inter-temporal approach, this requires taking the appropriate discount rate into account in the liability setting (Endres et al., 2007).

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2 Environmental liability is dealt with in the volume of the Encyclopedia on tort law and economics. See Faure (2009a).
4.3 Incentive-based Mechanisms

In many cases, the deterrent effect liability rules can give will not suffice in the case of environmental pollution, given information problems (see Section 5 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), Requate (2005), Schelling (1983a and 1983b) and Tietenberg (1985, 1990, 2000). For an overview of the literature, see Faure et al. (2006). It would go beyond the scope of this contribution to discuss the importance of this literature here. I should, however, state that most empirical studies that compare the performance of command-and-control with economic incentives programmes contain a significant bias towards finding in favour of the superiority of economic incentives over the command-and-control approach (Oates, 1990). For now, I simply refer to these economic instruments as measures that do not impose a direct legal constraint on the supplier’s behaviour; rather these measures function as incentives, conferring financial advantages or disadvantages on certain activities (Ogus, 1994b, p. 27). For an overview of the advantages and limits of economic incentive-based mechanisms, see Stewart (2000) and for a discussion of the implementation of economic instruments in environmental policy in developing countries, see Faure, Peeters and Wibisana (2006). A recent overview of 20 years’ experience of market-based environmental instruments in the US is provided in Freeman and Kolstad (2007). I will now discuss some of the literature concerning taxes on the one hand and tradable pollution rights on the other hand.

4.3.1 Tradable permits

We shall now pay some attention to two specific economic instruments, namely tradable 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 tradable systems is the pioneering work of Dales (1968). Dales proposed that a market for tradable permits would be organized by the government, whereby tradable pollution rights 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 envi-
ronmental 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 out the importance of monitoring and enforcement in the framework of a market for pollution rights. Also many other scholars, *inter alia*, Cole (2002) have stressed the importance of a property rights approach as the conceptual basis for a tradable pollution rights regime.

In addition to these papers sketching the theoretical benefits and the possible legal framework of a market for pollution rights, many subsequent contributions have analysed how some of these ideas have been implemented in environmental policy. Although most of the success stories in this respect come from the US, there was also (until the introduction of the EU Emission Trading Scheme for Greenhouse Gases) some experience with (some forms of) tradable pollution rights in the EU. 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, I 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 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 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). The SO₂ cap and trade programme was recently qualified as a ‘living legend’ of market effectiveness and supposedly led to substantial cost savings (Burtraw and Palmer, 2004). In the US, an Emission Reduction Credit (ERC) system was introduced which entitles the operator who emits less than the standard to some amount of emission reduction credits which can be sold (see Perman et al., 2003). As far as the emission trading system under the Clean Air Act is concerned, empirical evidence shows that the overall administrative costs of the system are significantly less compared with a traditional regulatory system (Ellerman, 2004). For further evidence on the design of emission trading in the US, see Nash and Revesz...
(2001, 2002) and for a more general appraisal, Tietenberg and Johnstone (2004). There is also an impressive body of legal and economic literature dealing with the efficiency of the emission trading scheme for greenhouse gases as introduced in Europe to deal with the climate change problem; that literature will be separately discussed in Section 8, dealing with the economics of climate change.

4.3.2 Environmental taxes
Finally, I can briefly refer to the findings in some of the literature on environmental taxes. I mentioned earlier, while 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 that environmental policy should be based on a tax system are concerned, I 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). A close linkage between the tax rate and emissions will be most effective, but will also increase administrative costs (Stavins, 2003). In practice, however, regulatory charges of a budgetary character are also used, which do not always have primarily environmental goals (see Faure and Ubachs, 2002).

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. The reverse was typically the case for 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 textbook form’. Hahn (1989a), moreover, claims that most emission charges or fees are used as a revenue-generating device for public services rather than as instruments of environmental policy, as prescribed by economists. The reason why taxes are relatively rarely used in the US is also discussed in a report drafted by Oates (1994) for the OECD. Most empirical evidence concerning the effectiveness of environmental taxes and charges comes 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, with half of this reduction due to the effluent charge. Similar success stories come from Germany (Brown and Johnson, 1984) to the effect that due to water effluent charges, there were significant increases in water treatment, leading most firms to comply with the existing emission standards. Since Germany (like 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 plants 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 agree with reports by Frey, who argues that environmental taxes lead to a considerable reduction of emissions into both the aqua system and the air (Frey, 1992, pp. 149–51). I can also point to 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. Bigano et al. (2000) argued that the use of generalized taxes to internalize externalities created by the power generation sector could generate important welfare gains since under the Belgian regulation, which they discuss, independent power producers escape most of the air pollution regulation.

4.4 Regulatory Standards

Another category of possible instruments relates to the standards discussed above in Section 3. 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. 26–7, pp. 214–44). 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 licence before the activity itself can be undertaken. The criteria for regulation will be further discussed below in Section 5; the way these environmental standards are introduced in legislation or licences and the various types of standards have been discussed above in Section 3.3.

4.5 Voluntary Compliance

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, I should refer to the work by Menell (1991) who points at the inherent limits of legal institutions in controlling environmental
risks. There is a growing body of literature on the effectiveness of voluntary compliance schemes and contractual solutions to environmental instruments. Cavaliere showed that voluntary agreements with industry offer many examples of overcompliance with respect to environmental standards. Even though such phenomena seem to be irrational at first sight, they appear less surprising considering firms’ strategies which are aimed at internalizing environmental quality (Cavaliere, 2000). However, he equally argues that due to the peculiarity of environmental information (more particularly, the fact that the green products are credence goods), an explicit agreement is necessary in order to establish monitoring and controlling procedures to verify the performance of firms. Nyborg also showed that if pollution is observable, but some emissions cannot be verified by the courts, voluntary agreements between a regulator and industry may be welfare improving compared to second-best emission taxes (Nyborg, 2000). Examples of these environmental agreements can now be found in many legal systems. Johnston (2001) discusses the efficiency of these environmental agreements as methods to facilitate the result of efficient bargaining between firms and the government. Hollick discusses environmental agreements as a valuable means to control environmental pollution (Hollick, 1983). Of course there is a wide body of literature on corporate voluntary environmental investments. The motivation for this can include corporate image building, regulatory pre-emption and production cost savings. Maxwell and Decker (2006) also show that investments in environmental technology to meet existing standards may increase if governments issue so-called responsive regulation. To some extent these additional investments may be socially undesirable, as a result of which penalties in case of non-compliance should be restructured to take these strategic environmental investments into account.

To a large extent environmental voluntarism and environmental agreements can also be considered beneficial from the perspective that they may lead to a so-called ‘crowding in’ of environmental norms. Frey (1997, 1999) showed that an important disadvantage of marketable permits and taxes is that they can have a negative influence on the moral behaviour of polluters. Under these instruments, polluters would only buy off their undesired behaviour and a crowding out would take place. Grepperud (2007) examined to what extent environmental regulation in terms of price mechanism (more particularly effluent charges) erodes moral motivation (crowding out) and suggests that a regime relying on voluntarism can do better since it increases the number of intrinsically motivated individuals and leads to a higher degree of moral motivation. Innes showed that systems of self-policing and self-reporting of environmental offences to government authorities have moreover the basic advantage that these systems can lead to a substantial reduction of enforcement costs (Innes, 2001).
4.6 The Choice of Instruments

Concluding this overview of possible instruments of environmental policy, I should first of all stress that there is an abundant literature concerning the choice of a particular instrument to control a specific externality problem. An excellent overview of these instruments and their combination is presented by Gunningham and Grabosky (1998). This literature discusses the 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 below in Section 5.

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 the 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). A combined approach has also been advocated with respect to liability rules and regulation (see generally Boyer and Porrini, 2001, 2002). Cole and Grossman presented a so-called total-cost approach to environmental instrument choice by focusing on both administrative and compliance costs (Cole and Grossman, 2002). Generally, differences between a ‘pricing’ and a ‘sanctioning’ approach have been examined by Cooter (1984).

Various studies also compare the relative cost effectiveness of a variety of the instruments I have discussed above and the way they could be combined under specific circumstances. For example, Nyborg argues that voluntary
agreements between a regulator and an industry may be welfare improving compared to second-best emission taxes, more particularly when emissions cannot be verified by a court (Nyborg, 2000). Bigano et al. (2000) examine a variety of market-based and regulatory instruments to control externalities produced by the power-generating sector in Belgium and quantify the efficiency and distribution effects of alternative policy instruments. Rousseau and Proost (2005) present a case study with respect to the textile industry in Flanders and compare combinations of regulatory instruments (emission taxes, emission standards and technology standards) with enforcement instruments (criminal fines, civil fines and transactions offers). They show that the relative cost efficiency of the various instruments they present essentially depends upon the information, monitoring and enforcement costs of each of the alternatives. Glaeser and Shleifer argue in favour of quantity regulations for governments with weak enforcement capacity. Allowing private parties to enforce quantity regulations will be beneficial given relatively low costs of verifying violations of quantity regulations for private enforcers (Glaeser and Shleifer, 2001).

5. THEORY OF REGULATION AND OTHER ASPECTS

5.1 Public Interest Criteria for Regulation

5.1.1 Criteria for regulation

We now ask under what types 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 the case of 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. On this, I suggest referring to the literature mentioned above which discusses the question of whether this ex ante regulation should take the form of taxes or the command-and-control approach via emission standards in licences. In legal practice, regulation plays an important role in controlling environmental harm. Similar economic criteria for regulation are advanced in Ogus’s book on regulation (1994b, pp. 29–46) and in various publications by Boyer and Porrini (2001, 2002).
5.1.2 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 has 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, if 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 as to what kinds of penalties have to be used to deter inefficient emissions has been addressed by Segerson and Tietenberg (1992). More specifically they address the question of how an optimal penalty structure can be achieved in the 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 offences has also been addressed in the many publications in this field by 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 also been investigated by Epple and Visscher (1984), who develop a model to measure the effectiveness of enforcement efforts. Gren and Kaitala (1997) examined the possible gains for the enforcing agency from disseminating information on its skill in detecting and convicting violators. The more recent literature on compliance with environmental regulations and enforcement strategies is discussed in the chapter on environmental crime in the Encyclopedia volume on criminal law (Faure, 2009b).

5.1.3 Effectiveness

We can also 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 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 had an equally significant 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. 307–23).

In addition, I can point to important literature following the work of Michael Porter, holding that environmental improvement does not necessarily come at the expense of competitiveness, but that, on the contrary, increased environmental performance will also lead to increased competitiveness of nations and industries (Porter and Van der Linde, 1995). This so-called ‘Porter hypothesis’ has been tested in many studies, most of which provide empirical support for the existence of a so-called environmental Kuznets curve (see Barbier, 1997). This suggests a relationship between environmental protection outcomes and national income. The hypothesis formulated in the literature surrounding this model is that there is a significant correlation between income and environmental performance (Faure et al., 2010, p. 98). Empirical evidence shows that where environmental pollution first rises as income increases, after a turning point, pollution levels will fall (see especially Esty and Porter, 1998, 2000). Esty and Porter showed in an extensive empirical study that economic development and environmental protection go hand-in-hand with improvements in a country’s institutions and more particularly the regulatory regime (Esty and Porter, 2005). The empirical evidence hence suggests that a country can benefit environmentally not only from economic growth, but equally from developing the rule of law and strengthening its governance structures.

5.1.4 Influence of environmental regulation on firm behaviour

The traditional view, in environmental law and economics, was that compliance with environmental regulation creates costs for industry, since firms are forced to internalize environmental externalities which they would in a positive transaction cost setting otherwise not do. This traditional view has, as I just mentioned, been challenged by Porter who argues that a better environmental performance can also improve the efficiency of the firm and therefore lead to higher profits (see more particularly Porter and van der Linde, 1995 and Porter, 1991). Telle (2006), however, argues that most of these studies on (beneficial) effects of environmental performance on economic performance suffer from serious methodological shortcomings as a result of which the conclusion that ‘it pays to be green’ would be premature. Using data from Norway, Telle argues that even though greener plants tend to perform economically better, the analysis provides little support for the claim that it is because they are greener. Also Schmutzler (2001) is critical of this so-called
Porter hypothesis and argues that environmental policy can only increase firm profits if several very specific conditions are met. These factors concern the type of policy involved, the costs of potential innovation projects and their effect on productivity and abatement costs. Several studies also deal with the presentation of reported expenditures for environmental protection. These expenditures are often cited as an assessment of the burden of current regulatory efforts. In a study of manufacturing industry, Morgenstern et al. (2001) found no evidence of the (assumed) understatement of true economic costs of environmental protection measures. Their analysis suggests some degree of overstatement of these costs. Hammitt presents a study concerning the costs for US industry of limiting chlorofluorocarbon (CFC) as a result of the implementation of the Montreal Protocol in 1987 (Hammitt, 2000) and found that estimates published before the international regime was adopted substantially overestimated the marginal costs of limiting specific CFCs, but that estimates published shortly after the adoption of the Montreal Protocol appeared to underestimate the marginal costs of limiting CFC consumption. The question of how accounting systems generally deal with the costs of complying with environmental regulations is dealt with by Joshi et al. (2001), who argue that there are substantial ‘hidden’ environmental costs embedded in other accounts. Inappropriate identification of these costs of environmental compliance is, so they argue, likely to distort costs in firms subject to environmental regulation. Canon-de-Francia et al. (2007) examine the ability of firms to adapt to a greater environmental demand such as may be derived from the implementation of new environmental regulation. They conclude, based on an empirical analysis of the implementation of the Act on Integrated Pollution Prevention and Control in Spain, that companies with greater technological knowledge are better prepared to adapt to the greater demands implied by new legislation. They also found that investor expectations were that firms’ adaptation to the requirement of the IPPC Act would have a negative impact on the financial results of approximately €1.700 million for their total sample.

All of these studies are of course closely linked to the question as to whether investments made by industry to comply with environmental standards have an influence on firms’ productivity and hence on their competitive capacity. This is an issue which also plays a role in the question of whether differences in environmental regulation may lead to a so-called race to the bottom, which I will discuss in Section 6. Related to this are studies that examine the influence of trade liberalisation on environmental performance. Strutt and Anderson (2000) argue that trade liberalizations would have a beneficial influence on the environment and reduce depletion of natural resources for the case of Indonesia until 2020.
5.2 Private Interest Theory of Regulation

5.2.1 Lobby for barriers to entry or lenient standards

Until now I have assumed that government regulation is always made ‘in the public interest’, meaning that the government will always make environmental regulation to cure the externality in an optimal way. The reality is, however, often very different. Sometimes regulation is passed even if it would not be necessary according to Shavell’s criteria for regulation, discussed above; in other cases, there is a valid argument for regulation, but the content of the regulation is inefficient. This phenomenon, namely that regulation is sometimes promulgated not in the public interest, has been examined by scholars of the public choice school. For the purposes of this contribution, it is interesting to discuss some of the literature that applies public choice and other interest group theories to environmental law. Many papers and studies examine the formation of environmental regulation on the basis of the influence of interest groups (see for example Bommer and Schulze, 1999 and Körber, 2000. See also the contributions in Schulze and Ursprung, 2001).

The starting point of the public choice analysis is that regulation is considered to be the product of supply and demand in a political market. On the demand side, there are the various interest groups who demand favourable regulation and on the supply side, the wealth-maximizing politicians who wish to favour those 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 that would have to be 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 the 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 the 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 environ-
mental 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 would 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 industry, realizing that environmental regulation is unavoidable, will cooperate in the development of the regulation and try to change the content 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 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 its own profits. Nash and Revesz showed that new regulations including a grandfather clause are inefficient. Limited transition relief may be appropriate in the context of environmental regulation, but the relief should, so they argue, be limited in time (Nash and Revesz, 2007), otherwise new regulations with grandfather clauses will retard the introduction of new, clean plants and will keep inefficient plants operating longer than they otherwise would.

As indicated above, the efforts of industry may go in various directions: sometimes regulation will take the form of 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, I can refer also to the function of licences, which are considered a central instrument in environmental policy. Moore (1961) pointed to 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 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 be directed towards 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 be targeted at 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 the case of zoning (Ault and Ekelund, 1988; Fischel, 1980, 1985).

Recent research by Binder and Neumayer shows that environmental NGOs exert a statistically significant impact on sulphur dioxide, smog and heavy particulates concentration levels, based on a country time-series regression analysis (Binder and Neumayer, 2005). This research hence provides empirical backing for the fact that public participation and NGO influence can effectively help to lower pollution levels.

5.2.2 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 Section 4, I indicated the variety of instruments that can be used to control environmental pollution, indicating that the literature suggests under what kinds of circumstances a particular type of policy instrument would be optimal. In practice, these ‘economic prescriptions’ (Hahn, 1989a) are not always followed. Also when market-based environmental instruments are introduced, this often happens because it serves the interests of particular interest groups. A general theory in this respect has been presented by Boyer and Laffont (1999). 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 for 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 existing firms in the market (Buchanan and Tullock, 1975 and see the comments by Coelho (1976a and b) 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 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 through 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 on a relatively significant 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. Moreover, the contents of the particular instruments and their stringency will also be influenced by the relative power of the interest groups involved. For example, the stringency of minimum standards on imported polluting goods will depend on the relative strength of the environmental group in the importing country versus the lobbying efforts of foreign firms (Lai, 2006).

A nice example of interest group influence on an environmental instrument comes from the Netherlands, where in 1996 a regulatory digressive energy tax was introduced. The result was that the larger the energy use, the lower the tax. The model therefore gives incentives to increase the use of energy rather than decreasing it and was clearly a measure to increase the competitiveness of Dutch industry, rather than serving any ecological goal (Faure and Ubachs, 2002 and 2005).

5.2.3 The choice for the level of government

The influence of interest groups will play a role not only as far as the contents of regulation are concerned, but also in relation to determining at what level of government action will take place. See generally, on environmental federalism from a public choice perspective, Revesz (1997a). Revesz argues that the logic of collective action suggests that under-representation of environmental groups is more serious at the federal level since they face large-scale free-rider problems and thus a loss of homogeneity of environmental interests at the federal level (Revesz, 1997b, 2000a and 2000b). 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 Lefevere argued that this may explain why some industries 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 where NGOs may oppose lenient standards. Once standards have been 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 union-wide to force (southern European) competitors to comply with these stringent standards as well and thus to create barriers to entry (Faure and Lefevere, 1995). This may explain why a lot of environmental regulations emerge from Brussels even in cases where economic theory would predict that the problem may better be dealt with at the decentralized level (see Section 6).

5.2.4 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 aimed at ‘victim protection’, such as strict liability and compulsory insurance (see Faure and Van den Bergh, 1990).

5.2.5 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 environmentalists coincide; hence, lobbying will not always result in industry opposing environmental regulation. Fourth, theoretically, a combination of public interest and private interest approaches 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.
6. ENVIRONMENTAL FEDERALISM

6.1 Criteria for (De)centralization

So far I have discussed the goals of environmental policy, assuming a harmonized legal system which would be applicable to all kinds of different situations. It is, however, obvious that environmental problems may vary greatly between communities. This brings us to 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 is always 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. See in this respect, *inter alia*, Jeppesen (2002), Van den Bergh (2000) and Revesz (2000a and 2000b).

The starting point of the analysis is usually 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 applications to fiscal decisions and environmental choices by Oates and Schwab (1988). Van den Bergh (1994) 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 to the bottom’ between countries would emerge to attract foreign investments. This race to the bottom would cause prisoners’ dilemmas, whereby countries would fail to enact or enforce efficient legislation. This idea, that various law makers in nation-states will create a competitive market for the supply of laws, has also been applied by Ogus (1999 and 2001).
6.2 Environmental Issues

These insights can also be applied to environmental problems, as was the case, for example, in the above-mentioned paper by Oates and Schwab (1988). Both general arguments in favour of centralization could play a role in 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 to the bottom argument). Whether this argument is valid depends on empirical findings which I shall discuss below. Van den Bergh’s arguments comply with the findings in another paper by Oates and Schwab (1988) who also 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 the local communities concerned would have other means to attract industry if they wished (relaxing regulatory controls in other areas).

6.3 Subsidiarity and the ‘Race to the Bottom’ Rationale

If I now turn to the actual division of competences, for example in Europe, I should first mention that the question whether action should be taken at a 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 I 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 for upholding this rationale is rather weak. Revesz has argued in many papers (1992, 1996, 2000a and 2000b) that competition between states
or localities has significant benefits and that there is no evidence of any race-to-the-bottom effect.

Repetto argues that pollution control costs are only a minor fraction of the total sales of manufacturing industries (Repetto, 1994). Moreover, 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 unionization of the labour force, have a much more significant impact on the location decision than environmental regulation. This empirical evidence has been somewhat contradicted by Xing and Kolstad (2002), 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.

Recent work by List et al. (2003) argues that being out of alignment with federal standards leads to an estimated cost of an area of between 0.7 and 1.3 new plants per year. Levinson (2000), however, argues that notwithstanding large differences between states in hazardous waste disposal taxes, there has not been a pollution haven effect. He provides a variety of explanations, the most important being that these state hazardous waste disposal taxes do not impose large employment losses on industries that generate waste. Millimet and List (2004) found that the cost of strict environmental regulations is lower both for countries with high employment (because they have relatively abundant cheap labour), as well as for countries with a greater concentration of employment in manufacturing (because these countries generate economies for manufacturing firms). These more recent studies therefore show that environmental regulation has a statistically significant effect on industry location, which somewhat contradicts the 1995 study of Jaffe et al. However, most of this recent empirical research focuses on competition between American states and between countries. For Europe, there is still less evidence (at least as far as the old Member States are concerned) of a race to the bottom.

As far as the federalization of environmental law in the US is concerned, I can point to an early work by 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, has
also recently criticized the various approaches that federal environmental laws have taken in controlling interstate externalities (Revesz 1996, 2000a and 2000b).

6.4 Environmental Standard Setting

At the European level there is, however, another reason for environmental action at the 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 citizens, irrespective of their individual preferences, this should not be realized through a harmonization of emission standards, as has been 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 of reaching a certain level of environmental protection may well vary with location-specific circumstances (Kolstad, 1987; Faure and Lefevere, 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 Lefevere, 1996). For a (theoretical) approach to harmonization of environmental law within the European Union, see Van Egteren and Smith (2001).

7. REGULATION UNDER UNCERTAINTY AND THE PRECAUTIONARY PRINCIPLE

A hot topic in environmental and safety regulation today is whether and how the regulator should intervene in the absence of scientific certainty concerning the effects of particular activities. This issue of so-called risk regulation has been the subject of much literature and is undoubtedly also debated in other contributions to this volume. A brief review of the literature in this domain will therefore suffice.
Lawyers often stress the importance of the so-called precautionary principle to deal with uncertainty in regulation. It can for example be found in article 174 (2) of the EC Treaty and can also be found in many national environmental legal systems and in international environmental law. The legal basis may be found – inter alia – in Principle 15 of the Rio Declaration which provides that ‘Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation’. Another example constitutes article 3 (3) of the well-known Framework Convention on Climate Change of 9 May 1992: ‘Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible costs’. Here it can be noted that the economic notion of cost-benefit analysis is linked to the (legal) precautionary principle. The principle comes into operation where there is a presumption, but as yet no clear and convincing scientific evidence, of certain undesirable environmental effects. Even in the absence of absolute proof, the precautionary principle dictates that tentative and scientific data are sufficient grounds on which to take measures to protect the environment. Many legal studies deal with the importance of the precautionary principle. See, in this respect, inter alia, the contributions in Fisher, Jones, von Schomberg (2006) and in Pâques (2007). Also de Sadeleer analysed the implications of many environmental principles, including the precautionary principle (2002). See also one of the many publications of Wiener on this subject (2004, 2007) as well as Christoforou (2004). Among the many other studies that deal with the precautionary principle or with risk regulation, I can also recommend Harding and Fisher (1999), Morris (2000) and O’Riordan, Cameron and Jordan (2001). Many of these studies deal more broadly with the question of how regulation should take place under uncertainty and do not only deal with environmental policy; therefore I discuss this broad issue only briefly here.

There are many criticisms on this precautionary principle from an economic perspective. Ogus (1995) has 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 of where these legal principles may collide with economic analysis. The principle may, in a strict application, indeed lead to overregulation in that costly precautions are taken without evidence that this will lead to a reduction in environmental harm, and may bring about a waste of scarce resources. A general problem here is the asymmetry of information over time. Costs of prevention and precaution are available today and are calculable, while the benefits and costs to the environment in the future may be diffuse.
and hard to estimate. Stewart (2002) is a strong opponent of strong versions of the precautionary principle since that requires regulators to prohibit or impose technology controls on activities that pose uncertain risks of possibly significant environmental harm. He argues that this decision rule is conceptually unsound and would diminish social welfare. According to Stewart, uncertainty as such does not justify regulatory precaution. An economic analysis of the precautionary principle is *inter alia* also presented by Pearce (1994) and in many publications of Viscusi (1992, 1998; Viscusi and Magat (1987)). Risk regulation more generally is also addressed by Eeckhoudt and Gollier (1995) and by Hood, Rothstein and Baldwin (2001).

An additional difficulty for the regulator in dealing with risk and uncertainty via regulation is that humans do not have access to all information and the capacity to elaborate and evaluate information is limited. This is motivated by the assumption of ‘bounded rationality’; as the human mind has limits, it is necessary to economize on information. The individual therefore suppresses, filters and focuses information and acts according to simplified rules of thumb. This has been made clear since the early writings of Kahneman and Tversky (1982). Increasingly, psychological experiments have shown how individuals react when it comes to judging risks, especially very low probability risks with disastrous consequences. This has led to an impressive body of literature, now known as behavioural law and economics. For recent overviews, see Slovic (2000), Sunstein (2000a, 2000b, 2002, 2005), Ogus (2005). This literature is highly relevant to risk regulation and explains why, for example, individuals tend to underestimate risks that they are familiar with or have accepted (smoking, food, drugs, car driving) and are much more sensitive to risks that have been highly publicized in the media, even if their probability of occurring is low (mad cow disease). It would go beyond the scope of this contribution to deal with this literature in any detail. For now, it will suffice to state that the general tenet of the law and economics literature (represented strongly in the publications of Viscusi; see e.g. Viscusi, 2005, but also in Johnston, 2003) is that regulatory policies often strike quite a different balance with an inordinately high cost per life saved. Viscusi and other law and economics scholars therefore plead in favour of a ‘rational risk policy’, also with respect to environmental risks. However, some law and economics scholars like Arcuri (2005, 2006) plead for a procedural version of the precautionary principle, arguing that the policymaker should err on the side of environmental preservation.

Many also pay attention to differences in risk regulation in the US and Europe. In this respect, see more particularly the various studies by Vogel (2003, 2004).
8. CLIMATE CHANGE AND EMISSION TRADING

I have already briefly mentioned above tradable permits as one of the "economic instruments" largely predicted by economic theory to cure externalities resulting from environmental pollution. The costs of climate change are for example addressed by Tol (2009). Again, one could easily fill one chapter of this Encyclopaedia by discussing all economic studies that deal with marketable permits and more particularly emission trading. In this respect, I can, for example, refer to the contributions in the volume edited by Sterner (1999) dealing with the effectiveness for environmental reform of market-based policy instruments and to the volume edited by Sorrell and Skea (1999), who deal with national and international experiences in emission trading. It is more particularly within the context of combating climate change that an 'economic' instrument like emissions trading has received a lot of attention. There are, however, also many other economic studies addressing the introduction of particular incentive-based mechanisms for reducing carbon emissions. For example, Koutstaal (1997) addressed the practical implementation of tradable permits for reducing carbon emissions. Policies and measures in international climate change policy are also addressed from a legal and economic perspective in Van Ierland, Gupta and Kok (2003). A critical law and economics analysis of the climate change problem and possible solutions has been provided by Stewart and Wiener (2003). They analyse the costs of investment in regulation to mitigate climate change and the US interests in global climate regulation. The most general law and economics analysis (with that specific title) of international climate change policy is provided by Schwarze (2001), who extensively discusses international emission trading, clean development mechanisms and other instruments to reduce carbon emissions. I have already mentioned that many critical economic studies have been published with respect to the so-called Kyoto Protocol, one of them being the above-mentioned study by Stewart and Wiener (2003). An equally critical study concerning the Kyoto Protocol was published by Victor (2001), who criticizes both the standards and the weakness of the monitoring and enforcement mechanisms. Other studies discuss the legal and economic consequences of the Kyoto Protocol. For example, Jackson, Begg and Parkinson (2001) discuss the so-called flexible instruments (and, more particularly, joint implementation) of the Kyoto Protocol. A critical assessment concerning the origin and contents of the Kyoto Protocol is provided by Grubb, Vrolijk and Brack (1999). The doctoral dissertation of Woerdman (2002) is entirely devoted to the implementation of the Kyoto mechanisms. Woerdman discusses both the institutional barriers and opportunities of the Kyoto Protocol, as well as legal barriers and opportunities. The dissertation therefore provides a truly legal and economic analysis of the Kyoto Protocol mechanisms. The practical imple-
mentation of the Kyoto Protocol in various countries at the policy level is discussed in detail in the contributions in Cameron and Zillman (2001). Many studies also analyse how policy could go beyond the Kyoto Protocol and which policy and legal instruments could be used to achieve further emission reductions. The role of institutions and instruments to control global change is discussed more generally, with a discussion of climate change control beyond the Kyoto Protocol, in Faure, Gupta and Nentjes (2003) and more recently the challenges of climate change policy and the effectiveness of instruments used so far are discussed by Douma, Massai and Montini (2007). They discuss, inter alia, the effectiveness of the EU Emission Trading Directive and also experiences with the implementation of the Kyoto Protocol in various legal systems. Several studies pay specific attention to the effectiveness of climate change policy in specific regions such as the European Union. For example, the contributions in Peeters and Deketelaere (2006) discuss in detail the system of greenhouse gas emission trading within the EU and pay attention to alternatives to reduce greenhouse gasses as well. Vrolijk (2002) provides a variety of case studies addressing the importance of economic instruments for electricity markets in Europe, more particularly in relation to climate change. For example Woerdman et al. (2008) discuss whether the allocation of emission rights via grandfathering violates the polluter pays principle and Kuik and Oosterhuis (2008) provide an estimate of the economic impacts of the EU emission trading scheme.

One recent topic in the area of climate change which receives a lot of attention today is the use of liability law or litigation more generally to force states or polluters to adopt measures reducing greenhouse gas emissions. In her dissertation, Verheyen (2005) addresses the possibility of using international law and more particularly the concept of state responsibility to address climate change damage. Smith and Shearman (2006) discuss the possibilities of climate change litigations in private and public law actions, discussing the various legal bases and scientific evidence.

9. CONCLUDING REMARKS – POINTS FOR FURTHER RESEARCH

This overview of the literature on environmental law and economics has unfortunately been 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 with the important area of international environmental law. A lot of economic research, especially in the area of international environmental economics, has focused on issues such as greenhouse
effects, CO\textsubscript{2} emissions, and so on. However, more research could 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 merits 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 focused on tradable 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 integrating the various instruments to control environmental pollution. Careful analysis is needed to establish under what specific circumstances various standards, taxes or liability rules are best suited to control environmental pollution and under what 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 where environmental regulation could be expected to be more in the public interest. Finally, I did not pay attention at all to instruments other than legal instruments which may play an important role in controlling the environmental risk. In this respect, I am thinking 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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