

# Evaluation of Legal Liability for Technological Risks in View of Requirements for Peaceful Coexistence and Progress

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Abstract

Legal liability for risk-generating technological activities is evaluated in view of requirements that are necessary for peaceful human coexistence and progress in order to show possibilities for improvement. The requirements imply, given that political decision making about the activities proceeds on the basis of majority rule, that legal liability should be unconditional (absolute, strict) and unlimited (full). **We analyze actual liability in international law for various risk-generating technological activities, to conclude that nowhere is the standard of unconditional and unlimited liability fully met.** Apart from that there are enormous differences. Although significant international liability legislation is in place for some risk-generating technological activities, legislation is virtually absent for others. We discuss fundamental possibilities and limitations of liability and private insurance to secure credible and ethically sound risk assessment and risk management practices. **The limitations stem from problems of establishing a causal link between an activity and a harm; compensating irreparable harm; financial warranty; moral hazard in insurance and in organizations; and discounting future damage to present value. As our requirements call for prior agreement among all who are subjected to the risks of an activity about the settlement of these difficult problems, precautionary ex ante regulation of risk-generating activities may be a more attractive option, either combined with liability stipulations or not. However, if ex ante regulation is not based on the consent of all subjected to the risks, it remains that the basis of liability in the law should be unconditional and unlimited liability.**

## 1. OVERVIEW

The two requirements for peaceful coexistence and progress that are assumed as the basis for our analysis are presented in Section 2. These are the requirement of informed consent and the requirement of liability in the absence of informed consent. We will refer to these requirements as “our evaluation criteria” or “our requirements.” We discuss the ethical (Section 2.1) and economical (Section 2.2) underpinnings that provide reasons why respecting the requirements is desirable. In Section 3 it is explained that, assuming these requirements and given that political decisions within nations on risk-generating technological activities are taken with majority rule, liability for these activities should be unlimited (full) and unconditional (absolute, strict). It is also pointed out in Section 3, and further elaborated in Section 6, that in view of these requirements no liability law can fully compensate for the absence of unanimity decisions among all those who are subjected to the risks, and that certain unanimity decisions will always be required. Section 4 offers a historical introduction to the notion of legal liability for risk-generating technological activities, revealing a number of common developments in the different legal orders since the 19th century. **Having thus set the stage, we evaluate in Section 5 a number of**

**current examples of liability in international environmental law, revealing that apart from enormous differences in liability for different activities, in none of the cases are the standards mandated by our requirements met. As a specific issue, we discuss the precautionary principle in environmental law in relation to liability law.**

Section 6 assesses the fundamental possibilities and limitations of liability and private insurance as instruments for bringing about credible and ethically sound risk assessment and risk management practices. We discuss how the limitations of liability lead to the desirability or necessity of precautionary ex ante regulation for risk-generating technological activities, but we also point out that the basis of liability in the law should remain unlimited and unconditional, as long as precautionary ex ante regulation is not based on the unanimity among all who are subjected to the risks. Section 7 provides concluding remarks.

#### **...4. HISTORICAL DEVELOPMENT OF LEGAL LIABILITY FOR RISK-GENERATING TECHNOLOGICAL ACTIVITIES**

Historically, liability for harm resulting from private activities has been based on principles of strict and unlimited liability. Thus, both in Roman, Germanic, and later in European law the basic principle of liability has always been that all who unlawfully cause harm to others should fully repair or compensate the harm, regardless of whether they had or had not been careful. **Hence, in these legal systems people have always been liable for all injury resulting from risk-creating activity, whether the activity had been careless or not.** It was also irrelevant whether the harm was caused by an individual himself or rather by his animals, servants, and such like.<sup>(13)</sup> This principle was discarded in the 19th century when the principle of “no liability without fault” was introduced. The latter principle is said to have its roots in the liberal individualism of the 19th century. According to Zweigert and Kötz,<sup>(14)</sup> this liberal individualism entailed the view that “a responsible individual's movement should only be limited by the imposition of liability in damages if he culpably failed to conduct himself in accordance with the general duty to act carefully.” This translated to the legal principle that a citizen may only be held liable for harm caused by otherwise lawful activities if he had acted with insufficient care, that is to say, if he was “negligent” or “at fault.” If on the other hand an act was performed in conformity with “the general obligation to act carefully,” that is to say, if “fault” was lacking, then any harm resulting from it should be borne by the victim.<sup>(14)</sup> In the United States as well as in England, the 19th-century introduction of fault liability as well as of limited forms of liability were explicitly motivated by the desire to promote the developing industry.<sup>(14-16)</sup> 3 Such an explicit motivation is less visible for the countries on the European continent. Apart from this, and apart from differences in degree, the transition from relatively strict and full liability to “fault” or “negligence” liability has also taken place in the countries of the European Continent, even though in at least some European countries liability for at least some risk-generating technological activities has always rested on a “strict” rather than a “negligence” rule. (The latter is demonstrated for the case of sparks from railway steam engines burning crops in Ref. 18.)

A particularly clear description of the 19th-century transformation of tort law in the United States is provided in the work of legal historian Horwitz.<sup>(15,16)</sup> An instructive example is provided by the changes in the conception of property rights.<sup>(15)</sup> Up until about 1800, property rights were characterized by the legal adage “use your property in such a way that you do not damage another man's property.” This implied that if damage did occur, the actor had to refund those harmed, even when the activity was lawful and had been performed with care. Hence, an actor was liable for any risk that he created. About 70 years later, the right to property had changed so as to imply above all the right to develop one's property for economic purposes, even if this would harm others. An actor could no longer be held liable for harm imposed upon others if the activity was lawful and if there was no evidence of carelessness (“fault”) in the performance of the activity. Although this new principle of “no liability without fault” was initially applied only to the activities of companies working under state grants, which were taken as evidence that the activities, though funded privately, were socially beneficial,<sup>(15)</sup> the new principle was subsequently extended to all lawful activities.

If it is now commonly stated that “traditional tort law tends to rest on fault-based regimes”,<sup>(19)</sup> then it must be clear that this tradition was only established in the 19th century. The same holds for two other elements of contemporary law pertaining to liability. Thus, although corporations with limited liability had existed in earlier centuries, their large scale introduction took place, and was enabled by legal changes, in the 19th century (see Refs. 16, Chapter 3; 20, especially the contributions of Diamond, Minchington, and Perrott; 21). Also, the introduction of legal limits to liability unrelated to the harm and of legally fixed amounts of compensation for damage are basically 19th-century developments.<sup>(15)</sup> It should be noticed that the developments described here—from strict to fault liability; introduction of corporations with limited liability; and the introduction of legal limits to liability and compensation—represent moves away from the requirements that form the frame of reference for the present article, taking into consideration that all these developments were severely contested at the time of their introduction.

The development of legal liability in the 20th century has witnessed certain tendencies back toward stricter, i.e., less-conditional forms of legal liability. Again the overall development has been similar in the different legal systems, in spite of national differences, and in spite of differences in style between the Anglo-Saxon and the continental European legal tradition.<sup>4</sup> An example of the tendency toward strict(er) forms of liability are the principles and regulations that govern products liability in the United States and in the EU. These are said to be based on strict liability, as opposed to fault liability, even though products liability remains in important respects conditional (see, on this, note 12). **Another manifestation of the trend is a tendency toward strict liability for so-called ultra hazardous activities, based either on sector legislation of which CERCLA and OPA in the United States are examples, or on general legal liability rules for dangerous activities (see Ref. 19, Chapter 7). At the international level, there are many activities aimed at strict(er) liability rules for risk-generating technological activities.** Despite this level of activity, general principles of strict liability have so far not been firmly established in international law. Even where they are said to exist, states have often been unwilling to apply them.<sup>(22-24)</sup> **The clearest expressions of strict liability in international law have taken the form of sector treaties, addressing the liability of specifically circumscribed technological activities, but so far only two of these have actually entered into force.** These two “exemplary” treaties will be analyzed in the next section in the light of our requirements (Section 5.1), but we will also consider areas of risk-generating activities for which there is a complete lack of established liability principles.

Concerning the limited liability of corporations, despite certain measures that have been taken to facilitate in certain circumstances the “piercing of the corporate veil,” the basic elements remain largely unaltered. These elements include that a shareholder cannot be held accountable for harm done by the corporation in excess of the value of his shares, and that employees including officers cannot, or only under stringent conditions, be held accountable for harm caused by the corporation. We will return to corporate liability in Section 6.

## **5. LIABILITY IN INTERNATIONAL ENVIRONMENTAL LAW**

In the present section we have two aims that both stand in the service of identifying possibilities for improvement of (international) liability law. Firstly, we want to illustrate that **there are enormous differences in legal liability in international law between different types of technological activities: whereas for some areas of risk-generating activities there is significant liability legislation in place, such legislation is virtually absent for other areas.** Secondly, we want to show that even for the areas for which a principle of strict liability is said to be implemented (to be discussed in Section 5.1), the standard of unconditional and unlimited liability that is mandated by our evaluation criteria, given the fact of political decision making at the level of nations, is not fully met.

A comprehensive overview of international law pertaining to liability and compensation for harm from technological activities is not aimed at and would be out of the scope of this article. For such overviews, see Refs. 22–27.

## 5.1. Oil Pollution and Nuclear Accidents

There exist international conventions regarding third-party liability for oil pollution from maritime transport and for nuclear accidents from the peaceful use of nuclear energy. These agreements have several elements in common (see Refs. 25, pp. 356–358; 28; 29), and have moreover served as models for several later (draft) conventions on civil liability for risk-generating technological activities.<sup>(25)</sup> Of the two agreements, only the one regarding oil pollution from maritime transport has been successfully relied upon by pollution victims.<sup>(25)</sup> Nevertheless, both agreements must be considered as relatively successful efforts to implement strict liability in international law, as none of the other liability conventions have entered into force, and as the prospects for their entering into force are on the whole considered dim by experts.<sup>(22,23,25)</sup><sup>5</sup>

The common elements of the conventions on third-party liability for oil pollution from oil vessels and for damage from accidents with nuclear facilities mentioned above are as follows:

- 1 Liability is “strict,” meaning that actors are not exempted from liability if they were not “at fault.”
- 2 Liability is “channeled,” meaning that only designated actors (the oil tanker owner and the nuclear facility operator, respectively) can be held liable.
- 3 The liability is limited to a fixed amount per accident.<sup>6</sup>
- 4 The liability (up to the limit specified) must be covered by insurance or by other financial security held by the actor to which the liability has been “channeled.”

In addition to these liability stipulations there is an international Oil Pollution Compensation Fund, financed by levies on imports of oil, from which damage may be compensated that exceeds the limit of the ship owner's liability, up to a further limit. The nuclear liability conventions hold the state in which the nuclear plant is situated liable for damage above the limited liability of the operator, again up to a limit.<sup>7</sup>

### 5.1.1. Evaluation

The first element of “strict” liability is consistent with our evaluation criteria. The third element, however, is not, given that the limits have been fixed at levels that are well below realistic levels of the costs of damage in the case of the more serious accidents.<sup>(28)</sup> This remains true after later revisions of the nuclear liability treaties.<sup>(29)</sup><sup>8</sup> The channeling of liability (point 2 above) can be sound, but only if the liability would be unlimited and the party to which the liability is channeled would have provided (financial) guarantees for recovery of injured parties in a worst-case accident scenario. This is actually not the case. For irreversible harm, such as deaths or irreversible environmental damage, our evaluation criteria require that all who may be harmed should consent to the means of compensation if harm occurs. Alternatively, the informed consent of those at risk might be obtained for being exposed to the risk, which may require to compensate them for being at risk.<sup>(30,31)</sup>

### 5.1.2. Governments as “Insurers of Last Resort”

In the scientific literature, legal limits to the liability for technological risks have been related to the circumstance that private insurance for larger amounts cannot be obtained. Radetzki and Radetzki,<sup>(28)</sup> quoting other authors, concluded that “the governments of the OECD countries have implicitly assumed the role of insurer of last resort for the top nuclear risk, thereby affording the industry with a subsidy” and that other industries are subsidized in similar ways.<sup>9</sup> They suggested that such public assumption of the top catastrophe risks of an industrial activity could be justified as a government policy for correcting a failing private insurance market. In evidence for the

nuclear case, they quoted calculations based on probabilistic safety assessments (PSAs) that purportedly show that the expected costs of accidents, including the large ones, are only a small fraction of the production costs of nuclear energy. Hence, the public assumption of the top risk of nuclear energy can be based upon “a political value judgment that these activities provide a social benefit that is greater than the social cost of the risks that they cause,” but that would otherwise not be undertaken due to a failing insurance industry.

### 5.1.3. Evaluation

The following comments can be made based on our evaluation criteria. (1) The political value judgment referred to should be based on the consent of all involved (or of those who truly represent them), rather than on a majority decision. (2) Given the possibilities for biased assumptions in the required PSAs, the reliability or trustworthiness of a PSA that is not backed by a commercial insurance may always be questioned. (3) Governments, by assuming the role of insurer of last resort, contribute to the persisting existence of the presumed market failure rather than to its disappearance.

## 5.2. Transboundary Movements of Genetically Modified Organisms

There is as yet no international liability legislation covering the environmental risks of using genetically modified organisms (GMOs) in agriculture. The Cartagena Protocol on Biosafety (CPB) adopted in 2000, and entered into force in 2003, addresses transboundary movements of GMOs. It is the first binding international legal instrument addressing some of the environmental and health impacts of modern biotechnology.<sup>(32)</sup> However, as a consensus on a liability regime under the CPB could not be reached, the CPB merely contains a clause stating that rules and procedures regarding liability and redress for damage resulting from transboundary movements of GMOs should be elaborated within four years after the Protocol's entry into force (see Refs. 25, pp. 362–363; 26, p. 45 no. 8; 33, p. 10). An ad hoc workgroup on liability was formed for that purpose, but in 2010 the goal of establishing a detailed liability regime under the Protocol has not been reached and could still be far removed.<sup>10</sup>

### 5.2.1. Discussion

It has been claimed<sup>(34)</sup> that liability for transboundary GMO trade should be unconditional and unlimited, and that liability insurance should be mandatory for GMO traders. This claim finds support in our evaluation criteria, given that there is no agreement about the deployment of GMOs in view of the environmental and other risks they may create. Even if the governments that are party to the CPB would decide, unanimously, on a liability and redress regime that is in some respect conditional and/or limited, then the resulting legal regime could not be justified by our evaluation criteria, as decision making at the national level is based on majority rule rather than unanimity rule.

## 5.3. Chemicals in the Environment

The European legislation on Registration, Evaluation and Authorisation for Chemicals (REACH) was first proposed in a European Community White Paper published in 2001.<sup>(35)</sup> The White Paper stipulated that the evaluation of chemicals (= testing and risk assessment) should be carried out and paid for by the industry. In the discussion that followed the White Paper and a subsequent proposal for legislation in 2003, different stakeholders defended widely diverging viewpoints regarding how strictly the REACH system should be implemented. While representatives of the chemical industry argued for relaxation of the originally proposed REACH procedure because they thought it too costly, environmental and consumer organizations urged for strict implementation because the social benefits of more extended testing, i.e., reduction of future harm, would in their view exceed its costs.<sup>11</sup>

### 5.3.1. Discussion

**Our evaluation criteria suggest that discussions like here, on precautionary (ex ante) regulation, should be coupled to the liability (ex post) aspects. Very often, and unfortunately so from the present article's perspective, the latter aspect is omitted from discussions on precautionary regulation. Examples are Refs. 35–48.**

For the case highlighted here, the following can be said. If producers think that ex ante risk evaluation should not be legally required for certain (classes of) chemicals because the costs of performing the risk evaluation would exceed the social costs of the risks posed by these chemicals, then they should prefer to accept unconditional and unlimited liability for these risks, this being the more cost-effective option for them. Conversely, if producers would accept this liability, then the relaxation of ex ante testing requirements might be more acceptable for other parties involved. The actual legal liability is, however, both conditional and limited. Thus, the European Directive on environmental liability (2004/35/CE) allows EC member states to exempt actors from liability for damage caused by an activity or an emission that was expressly authorized (Art. 8.4(a)), or that “was not considered likely to cause environmental damage according to the state of scientific and technical knowledge at the time when the emission was released or the activity took place” (the so-called risk of development) (Art. 8.4(b)) (see Refs. 49, p. 86; 50, p. 53; 51, p. 552).<sup>12</sup> **Clearly, this provides ample possibilities for member states to exempt actors from liability.** Karlsson<sup>(50)</sup> holds that “as soon as a producer has fulfilled his obligations under REACH, e.g., once a substance has been authorised, the so-called duty of care is considered fulfilled and liability claims can never be raised, regardless of the magnitude of any negative consequences in case of unexpected harm.”

### 5.3.2. The Precautionary Principle in Environmental Law and Liability

The above discussion can be extended to a more general consideration regarding the precautionary principle. One reading of this principle holds that “the proponent of an activity posing uncertain risk bears the burden of proving that the activity poses ‘no’ or an ‘acceptable’ risk before the activity can go forward.”<sup>(35)</sup> This reading finds support in our evaluation criteria, if it is added that what constitutes sufficient evidence of “no” or an “acceptable” risk should be judged by those who are subjected to that risk. Activities for which conclusive evidence of no, or an acceptable, risk cannot be provided would more easily receive the approval of those subjected to the risk if the proponents would guarantee recovery in the case that harm would materialize. There are many difficulties that may stand in the way of obtaining agreement on acceptable guarantees of recovery, having to do with problems of causation, of proof, of compensation for irreparable harm, and more. These difficulties, to be discussed in Section 6.2, should not obscure that the unanimity requirement (among those involved or among those who truly represent them) is necessary if progress in the sense of (expected) Pareto improvement is to be secured. Neither do these difficulties annihilate the insight that the requirements of peaceful coexistence and progress mandate that actors who proceed with an activity without the consent of those who may experience the consequences should face unconditional and unlimited liability for any resulting harm.

### 5.4. Climate Change Through Fossil Fuel Combustion

Principle 13 of the 1992 Rio Declaration on Environment and Development says that states shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage, and that states shall also “cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.”<sup>13</sup> In spite of this, there is a virtually complete lack of an international regime of liability for the adversarial effects of possible climatic change due to CO<sub>2</sub> production.<sup>14</sup> Nevertheless there are no fundamental legal obstacles that prevent the introduction of an effective regime.<sup>(52)</sup>

#### 5.4.1. Discussion

The complete lack of legal liability for climate change clearly is not in agreement with our evaluation criteria. This lack of liability implies that the recovery of people who will be harmed is not guaranteed, and that the costs of recovery from damage are excluded from the price of fossil energy. If such costs were to be included, even if only partially, into market prices by introducing market share liability for climate effects and by requiring coverage of liability by financial security, then this would surely affect the level of energy consumption and/or the choice for renewable energy sources.

### 6. POSSIBILITY AND LIMITATIONS OF LIABILITY AND PRIVATE INSURANCE FOR SECURING CREDIBLE AND ETHICALLY SOUND RISK ASSESSMENT AND RISK MANAGEMENT

The requirements that are assumed in this article are applied to assess the fundamental possibilities (Section 6.1) and the fundamental problems and limitations (Section 6.2) of liability, combined with private insurance, to secure credible and ethically acceptable risk assessment and risk management practices. The discussion of the problems and limitations will lead in Section 6.3 to a consideration of the role of precautionary ex ante regulation.

#### 6.1. Possibilities

In any assessment of the risks of an existing or proposed technological activity, it is unavoidable that assumptions are made that do not follow from direct observation, established science, and/or logic. Such assumptions are subjective in the sense that no one can be forced on the basis of empirical facts and logic alone to accept them. Such assumptions can be denied without denying any empirical or scientific facts or (deductive) logic.<sup>15</sup> Any risk assessment leading to a definite risk estimate must necessarily contain subjective assumptions in this sense. Outsiders are usually unable to evaluate the credibility of these assumptions and hence of the outcomes of an assessment. In view of this, it may be expected that someone who is exposed to the risk attaches credibility or trust to a risk assessment only if an individual or a group of individuals (i.e., a market party) has agreed to insure the risk for a premium that is related to the expected costs of the risk.<sup>16</sup> It would actually be in agreement with our evaluation criteria to allow only those hazardous activities of which the risks are completely covered by private insurance or other financial warranty, for instance, along the lines proposed by Meyer<sup>(53)</sup> for commercial nuclear power plants and LNG terminals. Actual applications of this idea in (American) environmental law exist, such as the bonding systems and liability systems described in Ref. 4, pp. 80–82. Under the condition described above, private insurers, while acting according to the established principles of risk management and insurance,<sup>(54)</sup> can be effective and trustworthy risk assessors and safety inspectors, as it is in their best interest (1) to determine insurance premiums that are both profitable and competitive, and (2) to set and supervise conditions and constraints aimed at optimizing the activity's safety. This consideration finds empirical support in Freeman and Kunreuther's<sup>(55)</sup> analysis of examples of private insurance of (liability for) environmental risks.<sup>17</sup> From their study it can be concluded that many environmental risks are readily insurable by the private insurance industry, provided that (1) there is sufficient legal/regulatory clarity about who is liable for what, and (2) governments do not interfere in the

insurance market, e.g., by installing guarantee funds fed with tax money in order to cover up (part of) the harm resulting from the environmental risk for which a private actor was supposed to be liable. (See also Ref. 56.)

In this section the focus is on the organizations that run high risk technological activities, such as nuclear or chemical plants, railway companies, etc. Examples of safety management issues in such organizations are provided in Refs. 57–58. If such organizations are held liable for the costs of accidents caused by their activities, then safety decisions obtain a financial translation. Such decisions are therewith brought on a par with all other management decisions, which, in private organizations at least, are ultimately governed by financial goals and considerations. This can provide for an effective intra-organizational mechanism for safety management and safety decision making. The mechanism can comply with our evaluation criteria, within limits that will be discussed in Section 6.2.

As the examples of Section 5 show, at present many hazardous technological activities proceed of which the risks have not, or at best only partially, been insured or otherwise guaranteed by or on behalf of the actors. Hence, enormous improvements are possible here, in spite of the problems and limitations that we will turn to now.

## 6.2. Problems and Limitations

The list of problems and limitations inherent in liability that follows below is not claimed to be exhaustive. Deeper and richer discussions of these and related problems can be found in Refs. 59–62. Our requirements leave open the following responses to such problems. Either the liability laws are “fixed” in ways that render the activities performed under those laws acceptable to all who are subjected to the risks. Below, we will make some suggestions. Or, if that is impossible or impractical, ex ante requirements and conditions can be imposed on the activities, either or not in combination with provisions for liability, to make them less dangerous and/or more acceptable to those subjected to the risks. If none of these responses succeeds, the activity should be banned altogether.

**1 Establishing a causal link. In order to hold an actor liable for harm resulting from an activity, a causal link must be established between the activity and the harm. If the causes remain unknown, or cannot be linked to an actor, then the harm will remain uncompensated.** Even if statistical evidence is available that a certain percentage of occurrences of a disease are caused by exposure to a chemical pollutant, problems remain, at least in the actual legal systems. As an example, **current tort law in the United States requires proof that a pollutant is more likely than not the cause of someone's disease, in order to hold the polluter liable for compensation (see Refs. 59, pp. 230–232; 60, p. 382). A consequence of this rule is that statistically proven harms from a certain pollutant remain uncompensated when the probability that an individual's harm was caused by the pollutant does not exceed 50%. A remedy for this particular case would be to award partial damages calculated in proportion to the attributable risk (see Refs. 60, p. 378; 59, p. 232).** As the latter remark, this would be challenging but not impossible to implement. To further increase the likelihood of compensation, the rules of evidence may be modified in other ways, the burden of proof may be (partially) shifted from those who are subjected to a risk to those who caused it, market share liability may be imposed, etc.

**2 Discounting future damages to present value. It has been stated by Ashford and Caldart that “even if the defendant believes that some plaintiffs will eventually sue and recover monetary damages, the costs of future lawsuits, when discounted to present value, may not be sufficient to provide a financial incentive to the defendant to invest now in the pollution reduction that would be necessary to avoid the lawsuits.”(59) A similar argument can be**



**mounted regarding the safety management of risk-generating activities such as nuclear and chemical installations, transport of hazardous substances, oil exploration and exploitation activities, etc.** For an analysis of this problem it is useful to distinguish between damage that is repairable, and damage that is not repairable, hence can at best be compensated. The first case is the least complicated.<sup>18</sup> Assume, in agreement with our requirements, that hazardous activities are only allowed if the worst-case harm is fully covered by a financial warranty held available by the actors themselves, by private insurance, or by yet other warrantors other than governments. If this warranty is invested in useful activities or assets (unrelated to the risk), its value will develop on a par with market rates of return. The assumption might then be accepted that the warranty will suffice to repair that same physical damage at any later time and it could no longer be claimed that harms falling in the future provide insufficient financial incentive to actors to reduce the risks generated by their activities.

Irreparable harm such as irreversible harm to the environment and to human health and life can at best be compensated. For full internalization of such external costs, potential victims must beforehand agree to how such harms, if they occur, will be compensated. Otherwise, it could never be claimed in a nonarbitrary way that the compensation, whatever the amount, is “full” or “fair.” At present, there is no ground for a claim that this condition is satisfied. If there were such ground, then the approach described above for repairable harm might in principle be followed here as well, although, because of the many uncertainties, it might be wise to periodically reassess whether the agreed-upon amount of financial warranty is still sufficient for adequate compensation in the worst possible case.

**3 Moral hazard in insurance. When the risks of a company's activities are covered by an insurance policy, the insured company may be tempted to behave in a more risky manner, resulting in more negative consequences (that the insurer must pay for) as would have occurred without insurance policy. This is called moral hazard.** Considered from the perspective of our requirements, moral hazard would not cause a problem if all potential harm would be repairable or fully compensable and if the worst possible accident would be financially covered. But as not all harm is repairable or fully compensable, **moral hazard, like “discounting the future,” limits the use of liability and insurance for bringing about ethically acceptable risk management. Strategies to reduce moral hazard do exist, such as coinsurance, co-payments, and deductibles, but it is questionable whether this can completely eliminate moral hazard.**

**4 Moral hazard in corporations.**<sup>(62)</sup> If corporate managers are insufficiently exposed to the negative effects of their business decisions, they may take decisions that generate more risks than is desirable from the perspective of the company and/or of society at large. There is reason to believe that such moral hazard in organizations actually occurs in modern business organizations. It **could be reduced by imposing upon managers and perhaps other employees, as well as on shareholders, more (financial) responsibility than is the case under the current legal regime that tolerates private legal persons with limited liability.** Important improvements in business and corporate law seem possible here.<sup>19</sup> To see more clearly both the problems and the possible solutions, a comparison with older legal forms might be inspiring.<sup>(20)</sup>

<sup>5</sup> Investment necessary to mount a case.<sup>(59)</sup> Lawsuits cost money. As a consequence not all cases will be brought to court, either because the harm is not severe enough or because the plaintiff or his lawyer does not want to run the financial risk of a negative court decision.

### **6.3. The Role of Precautionary Ex Ante Regulation**

One line of action in response to the problems attached to liability offered by our requirements is to **make adjustments or additions to the current liability laws so as to make the activities performed under those laws acceptable to all who are subjected to the risks. Depending in part on the nature of the risk, this may prove to be very difficult**, as the above exposition and discussion may show. **The other line of action is to adopt precautionary ex ante regulation aimed at restricting or constraining the risk-generating activities directly.** But which ex ante regulation, and how should it be enforced? How will compliance be guaranteed? How will compliance be inspected and controlled, and what will be sanctions on violation? Our first requirement calls for consensus on these issues among all who are subjected to the risks generated by the regulated activity. Without such agreement, the activity violates the requirement of informed consent, which means in virtue of the second requirement that the legal liability for those activities should be unconditional and unlimited. One important practical implication is this. **It is a frequent phenomenon that actors are legally exempted from liability as long as the activities are within regulations or if the activities are authorized by a government. An example mentioned in Section 5.3 is the EU directive on environmental liability.** Taking into account that such exemptions are based on majority decision making, they violate our requirements. For the same reason, **the exemption of liability for the “risk of development” in the EU directives on environmental liability and on products liability (Section 5.3) are violations of our requirements.**

## 7. CONCLUDING REMARKS

Using examples from international environmental law, we have tried to show that current legal liability for risk-generating technological activities deviates in several ways from the standard of unlimited and unconditional liability that is mandated by our requirement of informed consent and of liability in the absence of informed consent, given that the collective decision making within states about these activities relies on majority rule. Liability is not, and cannot, be developed into a full substitute for precautionary ex ante regulation. In view of our requirement of informed consent, and in order to safeguard progress in the sense of (expected) Pareto improvement, the decision making on such precautionary ex ante regulation should be based on the consent of all who are subjected to the risks of the regulated activity. As long as the actual decision making proceeds on the basis of majority rule within nations, our requirements call for unlimited and unconditional liability as the basis for liability in the legal systems.

We hope to have revealed opportunities and directions for improvements of legal liability for risk-generating technological activities and of risk management practices based on liability. Although such improvements cannot fully compensate for the negative effects of political majority decision making, they can at least quench some of these effects by promoting precautionary behavior and by enhancing the prospects of reparation or compensation for harm. In addition, such improvements will promote political decision making practices based on the consent of a larger fraction of those who are subjected to the consequences of the decisions made than is presently the case.

### Footnotes

...13 <http://www.unep.org/Documents.multilingual/Default.asp?DocumentID=78&ArticleID=1163>. The statement quoted in the text is a reiteration of principle 22 of the Stockholm Declaration on the Human Environment, which precedes the Rio Declaration by 20 years. See <http://www.unep.org/Documents.multilingual/Default.asp?DocumentID=97&ArticleID=1503>.

14 The trading system of CO<sub>2</sub> emission rights that has been installed in recent years cannot make good the lack of liability legislation, as the amount of tradable emission rights was not the result of a consensus decision among all who may experience the effects of CO<sub>2</sub> emissions.

15 This definition of a subjective statement is due to Van Velsen (see Ref. 2, pp. 49–50).

16 A particular example that may illustrate the statements in the text can be found in Ref. 53. Based on the U.S. Nuclear Regulatory Commission's Reactor Safety Study published October 1975, and assuming a cost of \$500,000 per casualty, the expectation value of a catastrophic risk would be as low as \$64 per reactor year (total possible damage \$64 billion, with a probability of occurring once in a billion years). Yet in testimony supporting the original passage of the Price-Anderson Act, the nuclear industry insisted that nuclear power would not be possible if the industry should bear the cost of liability above a limit of \$560 million. How can this claim be reconciled with the quoted outcome of the risk analysis?

17 The examples involved insurance for operator liability for health risks from asbestos during clean-up activities; property owner liability for environmentally contaminated property; liability for risks of groundwater contamination from underground petroleum storage tanks; and liability issues in lead-based paint abatement activities.

18 This case becomes more complicated if the determination of the worst-case scenario contains subjective assumptions, as will often be the case.

19 Recently, the Cambridge Journal of Economics published a special issue on the topic of corporate accountability and legal liability (Vol. 24.5, 2010) for which its (guest) editors claim that it restores corporate limited liability "to its rightful place as one of the most controversial parts of the global political economy."

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