This paper is part of the IRGC project "Ensuring the environmental sustainability of emerging technologies".
Suggested citation: Bergkamp, L. (2022). Liability's role in managing potential risks of environmental impacts of emerging technologies. In M.-V. Florin (Ed.) (2023). *Ensuring the environmental sustainability of emerging technologies* (Edited volume). Lausanne: EPFL International Risk Governance Center. DOI: 10.5075/epfl-irgc-298445

Liability's role in managing potential risks of environmental impacts of emerging technologies

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Introduction

This paper has been prepared in the context of EPFL International Risk Governance Center's (IRGC) project on ensuring the environmental sustainability of emerging technology outcomes. It discusses whether liability (or rather expanded liability regimes) could, and under which conditions, complement a portfolio of strategies, such as regulation, to manage emerging risks of emerging technologies and novel, innovative products. Could liability law take on a larger role than it currently has in managing these risks? For liability law to do so, it would have to generate adequate *ex-ante* incentives for good governance of innovation. However, liability laws are currently not designed to generate adequate *ex-ante* incentives in such cases. The paper thus focuses on the extent to which liability systems could be tuned to generate *ex-ante* incentives for good governance of innovation, and what the implications for technology developers and industry of such liability systems would be.

In this respect, a key issue is the generation of data before and after the introduction of new technologies and innovative products. Under civil liability law, this is the duty to investigate possible risks and disadvantages of new technologies. In theory, a technology developer or industry could be exposed to liability if (1) data is generated and (2) no data is generated, and it is hard to identify in a specific case whether the risk of liability exposure is larger with respect to the first or the second. From a theoretical perspective, it might be possible to identify an optimal point for data generation from the viewpoint of the liable entity, but, given that there is liability exposure associated with generating data, there is no reason to believe that this point will also be the optimal point from a public policy perspective.

The analysis presented in this paper is based on a rational, realistic approach to liability law and the likely response of potential liable entities to the incentives arising from liability exposure. The paper discusses both the possibilities and the limits of liability regimes in creating incentives for better management of the environmental sustainability of emerging technologies and innovative products, as well as possible approaches to mitigating the limitations of liability law and the pros and cons of such approaches. To illustrate the issues, a recent court judgment involving climate change is reviewed. The analysis suggests that liability law, given the self-interest of potentially liable entities and the epistemic and normative limitations of courts of law, is an inherently limited instrument in managing emerging risks of emerging technologies and novel, innovative products. Effective ways to eliminate (some of) the barriers to expanding liability exposure are likely to impose significant costs that need to be weighed carefully against their benefits.

1.

The issue

Invention, new technologies and innovation are critical to sustaining an increasing world population with ever growing demands. New technologies often provide substantial benefits to mankind, and enable human development, economic growth and prosperity. New technologies, however, also create uncertainty, because the experience with them is limited. In some cases, technologies turned out to have unforeseen adverse effects, in particular on human health and the environment. The issue discussed in this paper is what role civil liability can play in managing and controlling the risks of environmental impacts of emerging technologies.

The analysis presented here reflects common features of civil liability law in Europe. There is no uniform Europe-wide liability law, so liability systems and rules differ between countries. There are also commonalities, however, and the issues arising in the application of the rules tend to be similar. A broad distinction can be made between common law jurisdictions, such as the United Kingdom and the United States of America, and civil law jurisdictions, such as those of continental Europe.[2] This distinction is not relevant, however, to many of the issues discussed in this paper. A potentially more relevant factor is that liability systems evolve over time, and that the rate of evolution differs between jurisdictions. Despite (temporary) divergence on some issues, a discussion of common features and trends is useful to illustrate the issues arising

[2] For a discussion of differences between European and US civil liability litigation, see Bergkamp, L., & Hunter, R. (1996). Product liability litigation in the US and Europe: Diverging procedure and damage awards. Maastricht Journal of International and Comparative Law, 3, 399–418.

in relation to emerging technologies. The focus in this paper is chiefly on continental European liability systems. Liability of the legislature, executive government and regulators is not covered in this paper.

1.1 Regulation in general

To control the risks associated with emerging technologies, governments have adopted regulatory regimes. These regulatory regimes are typically specific to groups of products or sectors, and deal with technology outcomes such as genetically modified organisms, pesticides and other chemical substances. The instruments employed in these regimes typically involve duties imposed on the producer to investigate and test for potential hazards and risks, reporting obligation, permitting obligations, monitoring obligations, and notification obligations. In general terms, the objectives of these regulatory regimes are to identify and manage risks associated with emerging technologies, while allowing their deployment under certain conditions.

It has been recognized that regulatory approaches to controlling the risks of emerging technologies can have various disadvantages. These kinds of regulations generally require deep knowledge of the industries, and technologies involved. This knowledge is present within the industry to be regulated, but not necessarily in the regulatory agency. Agencies, to a not insignificant extent, may have to depend on industry representatives to obtain the information that enables them to regulate effectively and intelligently. This presents a risk of "regulatory capture," and a regulatory agency that is created to act in the public interest ends up advancing the commercial interest of an industry or sector the agency is charged with regulating.

Another disadvantage of regulatory approaches is their inherent "one size fits all" approach. Although regulations can be drafted to allow for flexibility and even adaptation, they typically impose a relatively rigid set of generic rules. These rules may work well for some cases, but in other cases they do not produce good results. Furthermore, the scope of regulations is an important preliminary consideration — if emerging technologies fall outside the scope of existing regulatory regimes, they may not be subject to regulation.

1.2 Regulatory duty to test

These kinds of regulations typically impose a duty to investigate or test for hazards or risks belonging to categories that have been defined in regulations. The producer is not required to examine whether a new product poses any new hazards or risks that do not belong to any of these categories or are not picked up by the test methods prescribed by regulations. In relation to testing, the same issue as discussed above arises: the regulations may work well for some products or technologies, but may be inadequate for other technologies. For instance, the testing of chemicals under the EU Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation was deemed to be inadequate for chemicals in nano-form, and the rules have been amended to address nano-substances specifically.

Regulatory duties to investigate and test not only involve generalizations necessary for a regulation to apply to a broad category of products, they also necessarily involve a trade-off between, on the one hand, the interest in the upfront identification and control of hazards and risks, and, on the other hand, the interest in allowing the introduction of new technologies so that their benefit can be reaped.

Due, in part, to the issues discussed above and the trade-offs involved in any regulatory regime, the question arises whether regulations for products of emerging technologies lead to an optimal or even an adequate upfront risk prevention or control. In some cases, the regulations may be deemed to be inadequate in managing risks of specific techniques or applications. In these cases, other regimes may be deemed necessary to provide for further incentives for risk management. Liability is such a regime.

1.3 Liability in general

There are three types of liability: administrative liability, criminal liability and civil liability. Administrative liability means that regulated entities may be exposed to administrative sanctions, such as fines or loss of a right, if they violate their regulatory obligations. Criminal liability involves criminal fines or imprisonment that may be imposed if corporations violate specific criminal statutes in relation to the endangerment of human health or the environment. The threshold for criminal liability is typically higher than for administrative liability.

Civil liability, which is the focus of this report, is a corporation's exposure to an obligation to pay compensation (or to do some act or refrain from doing some act), where the corporation breaches a duty of care under civil law, i.e., the law that governs the relations between private parties. Civil liability can be imposed if another private party brings (or threatens to bring) a lawsuit against the corporation concerned. The most common type of liability requires that the claimant establish that (1) it suffered a harm, (2) the corporation breached a duty of care, and (3) there is a causal link between this breach and the harm suffered by the claimant. In short, liability requires damage, negligence and a causal link. In relation to all three requirements, complex issues can arise, particularly in relation to products derived from emerging technologies.

Liability can be viewed as a remedy or sanction for non-compliance with regulations. Where it serves in that role, liability is another sanction for non-compliance imposed through the civil law system. A modern concept of civil liability, however, often goes beyond administrative violations. In this conception of liability, it functions as a system for filling in the gaps in the regulations and for supplementing regulations where they do not extend far enough. It might even be viewed as a system for correcting regulations where they are inadequate.

It is important to understand that regulation is an *ex-ante* approach that may also impose some *ex-post* obligations (e.g., an obligation to report if harm is caused), while civil liability is an *ex-post* approach (it kicks in only after there is harm or imminent harm) that ideally generates *ex-ante* incentives. Because liability threatens to hold companies that cause harm liable, companies have incentives to reduce the risk of harm, at least up to the point where the marginal costs of doing so is lower than the marginal cost associated with compensating the harms caused.

1.4 Could liability take on a larger role as a risk management tool?

As discussed above, in addition to regulation, liability law can play a role in managing the risks of emerging technologies and novel, innovative products. For liability law to do so, it must generate adequate *ex-ante* incentives for good governance of innovative technologies. Currently, due to issues such as evidentiary obstacles, liability laws are not designed to generate adequate *ex-ante* incentives in all cases; the question is whether tinkering with liability law to achieve an optimal incentive structure would be possible or desirable.

The analysis presented in this report focuses on three main questions:

1. What are the reasons as to why liability does not necessarily generate adequate *ex-ante* incentives for risk management? Barriers to liability's proper functioning.
2. How can liability systems be tuned to generate *ex-ante* incentives for good governance of innovative technologies? Possible remedies to liability barriers.
3. What are the implications of such liability systems for technology developers and policymakers? Implications of possible remedies.

The discussion of these questions is illustrated with considerations and examples that are specific to environmental effects of the products of emerging technologies. This combination raises a level of complexity that poses challenges to civil liability systems.

The generation and availability of data before and after the introduction of new technologies and innovative products is a key issue in relation to the questions. A company that introduces products derived from emerging technologies will have to comply with applicable regulatory requirements and generate the environmental safety data required by such regulations. Increasingly, product regulations require pre-authorization based on the provision of environmental safety data. Under civil liability law, the generic duty to investigate possible risks and disadvantages of new technologies may or may not result in the *ex-ante* generation of data not required by applicable regulations in specific cases. In theory, a company that places an innovative technology or product on the market could be exposed to liability (1) if no data is generated beyond regulatory requirements, but also (2) if data is generated where there is no regulatory requirement. In a specific case, it is hard to assess whether the risk of (1) is larger or smaller than the risk of (2). From the perspective of coherence of the law, ideally, there should be an optimal point at which one should be able to say that the data generated are sufficient, but not excessive. Given that there is liability exposure associated with generating data, however, the optimal point for a potentially liable entity is unlikely to coincide with the optimal point from a public policy perspective.

In this study, elements of liability law that impact this balance are identified and discussed. Adjustments to these elements to augment the incentives to generate data are proposed. This study then places the possible remedies in perspective and introduces the concept of balance. It also considers the public/private good (negative versus positive externality) distinction. Based on this broad analysis, the study discusses what liability systems can mean for the management of risks arising from emerging technologies from the perspective of technology developers and policymakers. The focus is on the challenge of damage to the environment (or, to use a somewhat vague term, "environmental sustainability"). Innovative products derived from emerging technologies may pose uncertain risks to the environment that manifest themselves only in the long-term or after addition or accumulation. There may be a lack of data and tools to perform comprehensive technology and risk assessment at the time when the technology is being developed, and even during early deployment. Could liability help to ensure that new technologies do not cause or contribute to environmental harms, and thus help to ensure long-term "environmental sustainability"?

2.

Barriers to liability's proper functioning

There are several reasons as to why liability does not necessarily generate adequate incentives to generate data *ex-ante*. Some of these reasons are generic and relate to the structure of the corporate law and liability systems, and some are specific to features of the current liability system. Below, we will review the most common barriers to liability's proper functioning as a system for creating data generation incentives.

2.1 Limited liability

Limited liability implies that the shareholders of a company, subject to limited exceptions, are not liable for the company's debts. Put differently, the assets available to a company's creditors are limited to those of the company, to the exclusion of the assets of its owners. Limited liability presents a problem for liability's proper functioning, because the incentives arising from the obligation to compensate harms caused will not have any effect on the company's conduct to the extent that the obligation exceeds the company's assets.

This problem is known as the "judgment-proof" problem, which arises also in parent-subsidiary relationships, as each legal entity, in principle, benefits from limited liability. In the context of emerging technologies, by establishing separate companies that commercialize the technology, corporate groups can shield their other assets. There are various solutions to this problem that are discussed in section 3, below.

2.2 Cost of lawsuits and small harms

On the side of the victim, called the "plaintiff" in liability law, there are incentives to sue a company that has caused harm, because the plaintiff could receive compensation. There are also disincentives, however, to initiating litigation, including attorney fees, court fees, possible counterclaims, and stress. If the harm, and thus, the amount that can be recovered through a law suit is small, the cost of a law suit weighs more heavily. This may be true even if a company in the aggregate has caused substantial harm. If many victims each suffer a small harm, none of them individually would have an incentive to sue. This is known as the rational disinterest phenomenon: when harm is wide-spread and individuals have a very small stake, they have no incentive to sue. The solutions to this problem are discussed in section 3, below.

2.3 Harm to the commons

A comparable problem arises if a company causes harm to common goods. If a company causes harm to the unowned environment, e.g., to public land or to wild animals, no one may have a claim on the company. Even if it is possible to assert claims, no one may have an incentive to sue because no one has suffered a compensable harm. In some jurisdictions, governments or their agencies may have claims against companies that damage public goods. Other solutions to this problem are discussed in section 3, below. Examples of products derived from emerging technologies that may cause harm to the commons include new hazardous chemical substances using advanced materials that could cause environmental harm if critical thresholds are exceeded, and products whose manufacturing process releases greenhouse gases that have adverse effects on the climate system.

2.4 Negligence

The dominant concept of liability is fault liability or negligence. Implicit in this type of liability is the concept of the duty of care. Under fault liability or negligence, it is not sufficient that a company caused harm – the company must also have breached a duty of care applicable to it. The flipside is that a plaintiff must prove that a company had a duty of care and breached it. This requirement serves as a barrier to holding companies liable, because it is hard to prove negligence and a plaintiff may fail.

The counterpart of fault liability is strict liability, also known as no-fault liability. Strict liability is imposed only in specific areas of liability law; fault liability is the generic regime by default. Needless to say, strict liability lowers the barriers to holding companies liable, because it eliminates the requirement that a company has breached a duty of care; it is sufficient that a company's conduct caused the harm.

2.5 Causation

Under both fault and no-fault liability, a plaintiff must prove that the company caused the harm that the plaintiff wishes to have compensated. The legal test for causation differs; a common test is the necessary condition test, or *conditio sine qua non*. Causation may be straight forward, where, for instance, a company has introduced an innovative product that turned out to be unsafe and caused a unique "signature" harm in victims. Generalized causation asks the question "does this kind of product (e.g., an innovative pesticide) cause this kind of adverse effect (e.g., abnormal level of death in fisheries)", while individualized causation asks "did the defendant's product (e.g., some innovative pesticide) cause the adverse effect suffered by the plaintiff (e.g., actual dead fish)".

There are several complications that may arise in determining causal links between technologies or products and harms. Many of these situations involve several or many causes and several or many victims, and they often arise in cases of environmental harm (or harm to environmental sustainability), including harm due to products derived from emerging technologies. These are common types of causal complications:

- **Overdetermined causation (preemptive causation and duplicative causation)**. In some cases, there are multiple causes for which multiple defendants are responsible. A textbook example is the firing squad — a man is hit by seven bullets simultaneously, and each of the bullets would have been sufficient to cause the man's death. An example in the area of environmental damage may be the long-term consequences of the use of chemicals such as plant protection products (or pesticides) in agriculture over a long period of time, which might result in diffuse, but widespread pollution of aquifers above non-observable effect levels for groups of chemicals in a large geographical area. In this case, the cumulative effect of only some of the chemicals might be sufficient to cause the harm, so some of the pollution is redundant from a causation viewpoint.
- **Indeterminate defendants**. Several or many companies have each marketed the same technology or product that is known to have caused injury. Victims, however, cannot tell which of these companies has caused the injury in their specific case because the technologies or products sold by the companies cannot be distinguished. In the agricultural pollution example set forth above, it may be impossible to determine which farm or farmer used the products that resulted in the contamination, so it may not be possible to hold any farmer liable.
- **Indeterminate plaintiffs**. A single company may have marketed a technology or product that is known to have caused injury to victims, but these victims are indistinguishable from other people suffering from the same injury caused by natural causes. An example is a product that causes an increased incidence of leukemia, which also occurs spontaneously in the population. Some asbestos-related cancers fall into this category (but not mesothelioma, which is most often caused by asbestos exposure and is therefore called a "signature harm").

For each of these problems there is one or more solutions, which are discussed in section 3, below.

A particularly difficult issue is deep causal uncertainty. In these kinds of cases, there is some evidence of an association between a putative cause and a potential adverse effect, but the evidence is not sufficiently strong. The *conditio sine qua non* test is not met. The causal link between neonicotinoids and harm to bee populations discussed in Sach's paper[3] is a case in point: there are several causes of harm to bee populations which act in combination, biological mechanisms are complex, scientific studies and risk assessments were biased, data and advice diverged, and decision-making was politicized.

2.6 Liability for harms caused by others

As a general rule, a legal entity is liable only for the harms that it caused, not for the harms caused by other persons. There are exceptions to this rule, however. An important exception is the doctrine of joint and several liability. This doctrine may apply where several companies engage in unlawful conduct that causes one indivisible harm. For instance, each of them marketed a chemical substance that has contaminated the environment, and each of them is liable for the entire harm caused. In the agricultural pollution example discussed above, if joint and several liability applies because the pesticide usage was unlawful (e.g., due to a higher dosage than permitted, or use outside the permitted season), each of the farmers that can be shown to have used the relevant pesticides could be held liable for all of the aquifer pollution.

Companies are generally liable for harms caused by their employees, subject to limited exceptions, and, in some instances, also for harms caused by independent contractors performing a specific task for the company. In general, companies are not liable for harms caused by their business partners, even if they have superior risk management knowledge and could have used their influence to prevent the harm. Novel concepts of liability extend the liability of multinational enterprises to the harms caused by persons that use their products or by business partners within their supply chain (see further section 3, below).

2.7 Burden of proof

Under liability law, the plaintiff typically bears the burden of proof. The burden of proof is to be distinguished from the standard of proof, which is the standard by which a court determines whether the burden of proof is met, and the burden of production, which relates to the obligation to make information available (known as "discovery" under US law). The burden of proof effectively implies the burden of persuasion.

Proving negligence and causation can be very challenging if the plaintiff does not have the necessary information and expertise. These are two separate issues, and require different kinds of solutions. In section 3, below, possible solutions are discussed.

2.8 Liability due to data generation

As noted above, there may also be liability associated with the generation of data. For instance, if a company conducts testing of a technology or product not required by regulation, and generates additional data on the technology or product, this data may result in the company being able to improve the technology or product or its use and application. However, it may also not enable the company to take any measures to reduce or mitigate the hazards or risks associated with the technology or products.

In these cases, the additional data could become a ground for claims in a later phase. For instance, if the additional data show that there is a hazard or risk associated with the technology or product, it could be argued that consumers or users should have been warned, but even if they were warned, it could be argued that the technology or product was defectively designed and should not have been placed on the market. If there is a regulatory obligation to disclose or report any such additional data the disincentives to generate the data may even be stronger, because it would imply that the data would be available to government agencies or even the general public. This issue may be particularly relevant in the context of ensuring environmental sustainability of emerging technologies, since it would tend to counsel against generating environmental safety data that is not required by regulation.

[3] See the paper written for the ESET project by Rainer Sachs, "Risk governance of emerging technologies: Learning from the past" (2022).

2.9 Claim expiration and long tail damage

Liability laws typically impose time limitations within which claims must be brought. If these limits are not respected, claims will lapse and can no longer be pursued. There are two types of such limitations: time limits triggered by the plaintiff's knowledge (i.e, of the injury and the defendant's identity), and time limits triggered by the lapse of time (e.g., all claims expire 30 years after the event that caused the harm). Complications arise if the relevant event extended over a long period of time and caused harm continually, or if it is not clear what the relevant event is (e.g., the product has been spilled into the soil but not yet migrated into the groundwater, which may be the harm at issue). There are ways to address such complications (see section 3, below).

In some instances, a long time may elapse between the exposure to some technology or product and the injury caused thereby becoming apparent. This is the problem of "long tail" harm. An example is cancer caused by exposure to a new chemical substance; it may take years and years before the cancer will manifest itself. In the case of emerging technologies, the issues posed by "long tail" damage are acute if it takes decades before both the environmental harm and the association with the technology become apparent. The potential adverse effect on the ozone layer of chlorofluorocarbons (CFCs), which had been in commercial use since the 1930s, was not discovered until 1985, as Sach's paper[4] discusses.

3. Possible remedies to liability barriers

Section 2 discussed barriers to liability's proper functioning. Due to these barriers, liability cannot or does not fully play its useful role in generating incentives for optimal or adequate risk management of emerging technologies and innovative products. Many of these barriers are common to the main legal systems of European nations. To improve liability's role in risk management, these barriers should be addressed. There is also a flipside to the possible solutions, however, since all of them have their pros and cons.

In this section, the focus is on possible solutions for the barriers identified in section 2. This discussion does not attempt to identify and evaluate possible negative side effects of each option, such as the negative consequences for incentives to innovate. In section 4 below, however, some comments are made on this problem, as there often is a balance to be struck between competing interests.

3.1 Solutions to the "judgment-proof" problem

An obvious solution to the problems posed by limited liability is abolishing limited liability. Unlimited liability would imply that the shareholders of the company would be liable for the company's debts, so there would be more assets available to satisfy the claims of the victims of the company's harmful conduct. Shareholder liability could be either joint and several liability or proportional to the percentage of each shareholder.

Abolishing limited liability, however, has broader implications for the economy and in particular for innovation. Put in simple terms, it would discourage risk-taking in innovation because it would shift more of the cost to the owners of the technologies and products. To mitigate this potential adverse effect on innovation, it has been proposed to abolish limited liability only in the context of corporate groups, which is known as "enterprise liability" and is similar to the theory of "economic unity" employed in competition law. Under this approach, natural persons that are shareholders would not be exposed to liability.

3.2 Cost recovery and collective claims

To eliminate the disincentives arising from the cost of bringing lawsuits, legal aid can be provided. A more appropriate way to address this issue, however, is to allow a successful victim to recover its cost from the defendant. In Europe, the rules regarding

[4] See the paper written for the ESET project by Rainer Sachs, "Risk governance of emerging technologies: Learning from the past" (2022).

cost recovery often provide for only limited, partial recovery. A more generous approach that covers the full, actual cost would improve the current situation.

Small claims could be handled in separate, low-cost procedures before specialized "small claims" courts. Where many small claims are against the same defendants and are related to the same technology or product, a collective claim procedure can be used to create economies of scale. In many countries, such procedures now exist.

3.3 Public interest litigation

To create incentives to initiate law suits against companies that have harmed the commons, regimes of public interest litigation have been established. In Europe, the right to sue is often granted only to legal entities specifically established for the purpose of protecting consumers or the environment. Citizens are often not able to bring such law suits, since they are not granted standing or are deemed not to have legally protectable interests.

3.4 Strict liability

Compared to fault liability (negligence), strict liability lowers the barriers to prosecution, because it eliminates one key hurdle towards recovery – it does not require a showing of a duty of care, nor of breach of any such duty. Consequently, liability is more likely to generate proper incentives for data generation, as it now is up to the company concerned to decide whether further data are in the interest of risk management and the company will be exposed to the consequences of its decision. Thus, in the case of emerging technologies, a shift from fault to strict liability would help to ensure their environmental sustainability, assuming the disincentives arising from regulatory disclosure and reporting obligations do not override the incentives arising from this shift.

Quasi-strict liability is fault liability under which the duty of care is so onerous that it is virtually impossible to meet it. For instance, if a court finds that a company has a duty to investigate extensively all possible hazards and risks of a technology or product prior to placing it on the market, in practice,

Examples of risks of products that were not known at the time the product was first introduced

- Risks for human health associated with smoking were not generally known when cigarettes were first produced at an industrial scale. Regulations did not require that these risks be investigated, but, once these risks became known, regulations required disclosure through labeling and notices in ads. Despite these more stringent regulations, tobacco companies were not necessarily deemed liable for health damage. In these cases, the defense of "risk assumption" and the question of the (intentionally enhanced) addictive nature of cigarettes were issues.
- The risks associated with inhalation of asbestos (mesothelioma, lung cancer) were not known when workers were exposed to asbestos in the workplace. When regulations imposed risk management measures, both asbestos producers and companies that exposed their workers to asbestos were held liable based on the theory that they knew or should have known of the risks prior to the regulations being amended.
- A group of chemicals known as per- and polyfluoroalkyl substances (PFAS), which were the outcome of emerging technology at the time, was used widely in non-stick cookware, water-repellent clothing, firefighting foams, food packaging, and other products that resist grease, water and oil. Most PFAS are non-biodegradable and persistent in the environment. Due to these properties, they have been regulated, including under the Stockholm Convention. In high concentrations, PFAS are associated with human carcinogenic and teratogenic effects. Under EU law, perfluorooctanoic acid (PFOA), for instance, has been classified as suspected to be carcinogenic, toxic to reproduction, persistent, bioaccumulative and toxic, and a persistent organic pollutant. At low levels of exposure, uncertainties about the effects of PFOA remain.

this duty cannot be met and fault liability is turned into something that resembles strict liability. For instance, assuming neonicotinoids cause harm to bees, if a court were to rule that the producers of neonicotinoids had an obligation to investigate this effect of their products (even though it was unforeseeable), producers would effectively be exposed to strict liability. As noted above, in the case of emerging technologies, a strict liability rule may be beneficial in terms of controlling the risk (or ensuring "environmental sustainability").

As liability shifts from fault to no fault, however, there may also be shifts in the causal requirements. For instance, under strict liability, there may be a tendency to apply stricter causal requirements, so that some of the harm will be deemed not to have been caused by it.

3.5 NESS and proportional liability

The problem of overdetermined causation can be solved by applying a causal test that asks whether the specific cause under review is a necessary element of a sufficient set (NESS). If, for instance, five units of a chemical were necessary and sufficient for the injury and each of seven defendants discharged one unit of the chemical, each defendant's one unit was neither necessary nor independently sufficient for the injury. However, each defendant's unit was necessary for the sufficiency of a set of actual antecedent conditions that included only four of the other units, and the sufficiency of this particular set of actual antecedent conditions was not affected by the existence of two additional duplicative units.

Problems of indeterminate plaintiffs and defendants can be resolved by concepts of proportional liability. Under these concepts, liability is not treated as an all or nothing decision, but as a matter of degree. The concept of relative risk can be used here – if the defendant's act increased a background risk by 25%, the defendant is responsible for 25% of the harm if it materialized. In cases involving indeterminate defendants, the market shares of the companies concerned can be used as a proxy for proportional causation – each company is liable for a portion of the injury that corresponds to its market share (e.g., if a company had a 25% market share, it is liable for 25% of the damage).

These solutions can be directly relevant to environmental harms caused by products derived from emerging technologies. In the case of multiple sources of pesticide pollution resulting in diffuse, widespread environmental contamination, for instance, theories of proportional liability can be employed to determine the share of the damage that should be imputed to each pesticide user. Each user's percentage of the total usage of the pertinent pesticides could be a rational basis for allocating liability.

3.6 Expanded joint liability, liability for other companies, and director liability

Under the theory of joint liability, a company can be held liable for a single indivisible loss for which it is only partially responsible and which has been co-caused by a possibly large number of other parties. A company that bears a small share of the responsibility for a plaintiff's injury can be compelled to pay all of the damages. Joint liability enables plaintiffs to seek out defendants with large resources ("deep pockets"). Note that joint liability goes a step further than proportional liability and is more favorable to victims. Joint liability could be expanded by relaxing the conditions applicable to finding a single injury. For instance, if the aggregate loss suffered by all victims jointly is considered an indivisible harm, joint liability would apply.

Joint liability only covers single indivisible harms to which the defendant contributes, and does not extend to harms caused entirely by other entities. Under novel liability concepts, however, damage caused by other entities may entail the liability of, typically, a large multinational company (also known as a "deep pocket"). These other entities may be direct or indirect customers for the company's products or other business partners within their supply chain. Concepts such as corporate social responsibility, product stewardship, extended producer responsibility and supply chain responsibility provide a basis for such novel liability theories. Under the theory of supply chain liability, a multinational corporation is liable for harms caused by the business partners up and down its supply chain, typically based on the doctrine of negligence (but the standards may be demanding so that it effectively becomes quasi-strict liability). The idea is that large multinational corporations have a duty to take measures to prevent harms caused by other entities over which they have some level of control; if they fail to meet this duty and harm arises, they are exposed to liability.

Expanded director liability would result in directors having individualized incentives to ensure that the company takes adequate measures to prevent and manage hazards and risks. Director liability could be triggered on the basis of the same standards that apply to the company's liability. In theory, this kind of liability could alleviate the problem that directors are inclined to allow a company to take too much risk, e.g., because it increases profits and thus their own compensation.

3.7 Alleviating the plaintiff's burden of proof

There are several ways in which the law can assist a plaintiff in meeting its burden of proof. First, the defendant can be ordered to produce information relevant to the plaintiff's claim. This is particularly relevant in cases in which the defendant controls the relevant information. Second, once the plaintiff has made a *prima facie* case that its claim has merit, the court may shift the burden of proof to the defendant. Third, the court may lower the standard of proof in complex cases and, for instance, allow the plaintiff to proceed on the basis of the "weight of the evidence" approach.

The precautionary principle also provides a way to alleviate a plaintiff's burden of proof. Where there is scientific uncertainty about the pertinent causal relation and the plaintiff has been able to demonstrate some sufficient association, a court could decide to shift the burden of proof to the defendant. If the defendant is unable to disprove a causal link, they will be liable. In cases involving genuine deep causal uncertainty, such a reversal of the burden of proof would invariably result in defendants being held liable for harms they may not have caused.

3.8 Exoneration from liability

To counter the disincentives arising from the generation of additional data, a company could be shielded from additional liability exposure arising from such data. For instance, a company could be exonerated from additional liability if it has demonstrated to the regulatory authorities that it made responsible risk management decisions based on the additional data.

3.9 No expiration

There is also a possible solution to the problem of long tail damage. If a company knew of the risks posed by its technology or product, but failed to take appropriate action, the law could provide that the claims plaintiffs may have in relation to such risks will never expire.

3.10 Human rights

Recently, courts in The Netherlands have based civil liability on human rights, instead of conventional civil liability theories. In many ways, resorting to human rights represents the "nuclear option," because it upsets the concepts and rules that otherwise apply. First, the Dutch Supreme Court confirmed the ruling in Urgenda's case against the state of The Netherlands. Based on an imminent breach of the human right to life, the state was ordered to increase its emission reduction target from 20% to 25% by the end of 2020 (relative to 1990 levels).

Then, the The Hague District Court ruled in favor of Friends of the Earth in a case against Shell. Shell was ordered to ensure that by 2030 its group-wide and world-wide carbon dioxide (CO_2) emissions are reduced by at least 45% relative to 2009. This obligation applies to Shell, all of its subsidiaries, all of its suppliers, and all of its customers (thus, scope 1, 2 and 3 emissions). This judgment is currently being appealed. The Hague Court of Appeal has full authority to confirm or overrule the judgment in first instance. In either case, it is likely that the case will go to the Dutch Supreme Court, which may review only issues of law.

Climate judgment against Shell

The climate judgment against Shell was revolutionary, even after the Dutch Supreme Court's ruling in the Urgenda case. The reasons as to why it was revolutionary become clear once we compare this judgment to conventional liability rules.

- In Shell, the legal basis for liability was not negligence, but a court-invented "social duty of care" which boiled down to the obligation to respect the human right to life. To this end, the court construed this right to encompass a "right to a safe climate." Consequently, no complex analysis of the benefits and costs of taking preventive measures against climate change, which would ordinarily occupy the court, had to be done.
- The court found that CO_2 emissions cause "dangerous climate change" and violate the right to a safe climate. A safe climate was defined with reference to the Paris Agreement's target of limiting the temperature increase to 1.5 °C. It found that Shell would encroach on the right to a safe climate in the future. To compute how much Shell's emissions should be cut back the court applied the concept of the carbon budget, imposed a pro rata reduction obligation on the basis of equality, and used a linear reduction pathway. Again, in this way, all complexities could be avoided that are typically associated with arriving at individualized obligations for future harms to the commons.
- Having found a right to a safe climate, the court did not have to worry about the question as to what the harm is. Friends of the Earth did not have to demonstrate any harm or threatened harm; a mere reference to the Intergovernmental Panel on Climate Change (IPCC) and other reports on the possible consequences of global warming were deemed sufficient to establish a relevant possible future injury to the right to a safe climate. The precautionary principle played a role in the court's reasoning as well.
- As a result of the court's rights-based reasoning, the question of the causal link between the emissions for which Shell is deemed responsible and the (future) damage to the climate became moot. It was no defense that Shell's emissions are not a *conditio sine qua non* for the threatened harm, nor that global emissions are not projected to decrease to the level necessary for reaching the 1.5 °C limit. Shell was held to bear a partial responsibility for reducing its emissions and the causal analysis was limited only to Shell's portion of the currently foreseeable harm to be prevented by it.

In short, by shifting the legal basis to the human right to a safe climate, the liability regime changed fundamentally and many of the complicated issues disappeared. Because of this fundamental change of civil liability law, the court has been criticized for overstepping its authority, ignoring the separation of powers, acting as an unauthorized substitute-legislature, breaching the rule of law, and setting aside democracy. These issues will be debated before the The Hague Court of Appeals in the fall of 2022.

4.

Implications of possible remedies

In theory, if all of the remedies discussed in section 3, above, were implemented, liability could provide stronger incentives for innovative companies to anticipate possible hazards and risks of their products. Indeed, liability could play a stronger role in managing the risks of emerging technologies and innovative products by increasing the extent of responsibility to be borne by the company if harm arises.

The implications for policymakers would appear to be clear — they should implement the remedies discussed in section 3, above, to give liability a stronger risk management role. However, the analysis provided in this report is incomplete and has not considered the possible adverse effects associated with the remedies. In other words, comparative and marginal cost-benefit analysis would have to be done to determine which possible liability reforms are attractive. A generic problem with all possible remedies is that they may have a chilling effect on inventers, innovators and technology developers — the fear of exposure to potentially large claims may deter them from engaging in invention and innovation. This chilling effect is undesirable from a public interest perspective because it would deprive society of the benefits of innovative technologies and products. At the same time, the preservation of the environment and the pursuit of environmental sustainability are also major public interests that are protected by laws and that many governments have stated they wish to prioritize above economic interests, albeit not at any cost.

Unavoidably, there are countervailing considerations. For liability to play a role in ensuring the environmental sustainability of emerging technologies, the judiciary should be both normatively and epistemically legitimized in expanding its mission. This implies that the judiciary should have been granted the authority to apply liability regimes to the issues raised by environmental sustainability of emerging technologies. It means also that the judiciary should have access to all necessary information, data and analysis, understand everything that was provided, and be able to make sound decisions on that basis. Needless to say, this is a tall order. Judicial resort to human rights (also called “humanrightsization”) in the Dutch climate cases has been controversial precisely because it raises issues of judicial authority (may a court expand the undefined right to life to include a specific right to a safe climate) and the epistemic capabilities of judges (can judges understand the relevant science and climate policies, and make sound, informed, balanced and science-based decisions).

The task for policymakers may not be to revolutionize the liability system, but rather to adjust the rules in an iterative, adaptive manner, based on the effects on both compensation of harms (in this context, harms to the environment or “environmental sustainability”) and the rate and nature of innovation. Some, but probably not all of the features discussed in section 3, above, could be included in such a programme.

For companies developing innovative technologies the challenge would be to distil clues or signals from the abstract, general set of liability rules. If a company is to be encouraged to generate additional data beyond regulatory requirements, it needs to be able to determine whether data generation will avoid liability in the future. Such assessments are hard due to the imprecision of liability standards. Nevertheless, two general rules of thumb for technology developers might be derived from liability law:

- Make sure you are on top of the science, monitor new scientific publications relevant to your technology and products, and analyze their implications; and
- If there are gaps in the data on the technology or product, consider generating additional data.

This guidance is particularly relevant with respect to ensuring the environmental sustainability of emerging technologies because there tends to be more uncertainty around environmental impacts in these kinds of situations, particularly with regards to long-term impacts.

A liability system that is well adapted to addressing harms caused by outcomes of emerging technologies (such as harm to the environment or environmental sustainability) should be balanced, reasonable and predictable. Below, each of these concepts is discussed in more detail. Before doing so, a few comments on public goods are in order.

4.1 Public goods

A private good is characterized by rivalry and excludability. A public good, on the other hand, is

characterized by non-rivalry and non-excludability, with semi-public goods having only one of these characteristics. Information, by definition, is a semi-public good, because there is no rivalry in its use; excludability determines the value of data to a private entity. If a company generates data on its technology, such data may be a private good owned and controlled by the company that paid for it; competitors may not be able to benefit from the company's efforts.

The trouble with data on a technology's or product's environmental and health effects, however, is that the information may have to be disclosed either to be effectively deployed or as a matter of law. Where that is so, the data becomes a public good available to all. This creates a "free rider" problem, as only one company paid for the data and all other entities can use it for free. The free rider problem generates a disincentive for data generation by a single private entity.

Despite the free rider problem, data may still be generated by companies (but not necessarily shared with others) if they perceive there to be a net benefit, for instance, on one of the following grounds:

- The company is a market leader and can reap other benefits from data generation, such as increasing its opportunities in the marketplace, using the data to shape industry standards that benefit the company itself, or building its reputation as a responsible corporate citizen.
- The company that generates the data has a significant timing advantage, because it will have access to the data earlier than its competitors and, thus, can make adjustments before they can, which gives the company a competitive edge.
- The data generation is funded by a group of companies, so that the cost can be spread over a number of entities.
- Under the applicable law, the company that generated the data is entitled to require that other entities using the data pay a cost share.

The lesson to be learned is that, if the liability system is to generate incentives for the creation of data by private companies, and such data are a public good, additional legal or regulatory regimes may be necessary to ensure that data are effectively created and made available to all those that need access. It is one thing for a company to generate additional data in its own self-interest but quite another thing for a company to generate data in the public interest. This notion may have implications for data generation for the purpose of ensuring the environmental sustainability of emerging technology outcomes.

4.2 Balanced and reasonable

If all of the amendments discussed in section 3, above, were made, the liability system would provide significant incentives to manage the risks associated with emerging technologies or products, including incentives to generate additional data beyond the data required by regulatory requirements. Probably, such a novel, expansive liability regime would serve the purpose of ensuring environmental sustainability of emerging technologies. However, these amendments would also have broader effects on companies and particularly on their inclination to develop and market innovative technologies and products.

In general terms, increased liability exposure may imply disincentives to innovate and place innovative technologies and products on the market. Whether the improved incentives to invest in risk management of innovative technologies and products outweigh the disincentives to innovate and place innovative products on the market, is an empirical question that goes beyond the scope of this report. Given that both innovation and risks management are critical to society, the incentives and disincentives should be in balance. This challenge, of course, is not unique to liability systems; regulatory regimes struggle with the same issues. Take the EU Chemicals Strategy for Sustainability – it is aimed at ensuring an as of yet undefined "toxic-free environment" in Europe, but it is unclear how the additional regulatory requirements will impact technology development and the industry's innovation potential.

The requirement that the liability rules be reasonable implies that liability rules should meet the basic demands of justice, both where companies escape liability in violation of the demands of justice, and where they are held liable in violation of the demands of justice.

4.3 Predictability

For an improved liability system to generate specific incentives to generate data beyond regulatory requirements, it needs to be not only balanced and reasonable, but also predictable. If technology developers are unable to predict whether liability will be imposed in a specific case, they will not be

able to take liability exposure into account in their decision-making. In other words, ideally, technology developers should be able to tell whether a specific action or measure they could take will in fact reduce the company's future liability exposure.

Case law does not necessarily guarantee predictability — the Dutch climate cases are the prime example. Courts can base their judgments on novel theories not previously entertained and on some issues, they issue inconsistent judgments. Thus, one of the main issues with liability law is that it tends to be relatively unpredictable in terms of outcomes in specific cases, in part, because liability rules are often applied *ex-post* by judges with no prior scientific training, which creates the risk of hindsight bias. Technology developers need information on liability exposure *ex-ante*, i.e., before any problems occur and in many cases years before products even reach the marketplace. Liability laws are not written in terms that are sufficiently specific for technology developers to predict liability exposure in the future. Given that liability is applied by the courts only after the fact (*ex-post*) when a case is brought and there is either harm or threatened harm, sufficiently precise decision rules that technology developers need to make decisions, will often not be available.

A key question, thus, is whether the predictability of liability exposure in the future can be improved. In other words, what could be done to make liability exposure so predictable and specific that it can be translated into specific requirements for technology developers in terms of the design, applications and use instructions of specific innovative technologies and products? This would appear to be an enormous challenge, given liability's stop-gap function and mode of operation. And if it can be done, the argument will be made that it is more appropriate to enact a regulation imposing these requirements.

To improve the predictability of liability exposure, the general liability rules could be supplemented with specific exonerations or with specific conditions for liability in relation to specific innovative technologies and products. An example of a possible exoneration rule was discussed in section 3, above: if a company generates additional data beyond regulatory requirements and on the basis of such data adjusts its risk management practices, it could seek regulatory approval, which, if granted, would grant exoneration from liability on the basis of the additional data. Further, more generally, the liability rules could be adjusted to accommodate the specificities that are relevant to an innovative technology or product; a company's entire risk management programme could be subjected to review and approval, with approval functioning as exoneration from liability. This combination of *ex-post* liability rules and *ex-ante* regulatory conditions is unusual. There is some precedent for similar arrangements in connection with the so-called regulatory compliance defense or permit defense in liability cases.

4.4 Implications for stakeholders

To a significant degree, liability's role as an instrument to manage the environmental risks of emerging technologies is a function of one's view on law as such. There is the idealist's view and the realist's view. In the idealist's view, liability law is a flexible instrument that is able to respond to new challenges, including those posed by the risks associated with emerging technologies. The realist, however, pays attention to how liability works in the real world. While the idealist asks, "how can liability respond to emerging risks," the realist asks "how does the liability system, in fact, respond to such risks." To the realist, the key question is "what will a judge rule" in a particular case, not "what should a judge rule." In other words, in the realist perspective, liability's actual limits take center stage.

In a realist perspective, liability's implications for stakeholders are a function of the incentives that are actually generated by the system. Liability is an exogenous (as opposed to an endogenous) factor in the decision-making of a person that is actually was exposed to the consequences of liability. Liability law does not protect all interests, and targets only some groups of potentially liable parties. As discussed above, liability law is characterized by a series of institutional, procedural and substantive limitations, which distort the incentives that liability can generate for damage prevention, even where risks are foreseeable. This explains also why the guidance that can be provided to technology developers, research funders, financial investors and industry is fairly general and abstract, and chiefly related to investigating possible causal links between the technology under development and environmental risks. Generating information, however, can itself increase, rather than reduce, liability exposure and related legal risks. Guidance to policymakers can be more specific, as discussed, but improvements of the liability system unavoidably involve trade-offs and value judgments.

5.

Conclusions

The analysis has come full circle. Based on the assumption that regulations are not necessarily sufficient to generate adequate incentives for the proper management of the risks of innovative technologies and products, we set out to determine how the liability system could be improved to better supplement the regulatory regimes in managing the risks of emerging technologies. We analysed what role liability law could play in supplementing the regulatory incentives and encouraging companies to generate additional data beyond regulatory requirements. The analysis resulted in the conclusion that liability law would have to be adjusted to assume the role of supplemental incentive generator.

Expanding this line of thought, multi-faceted analysis suggested that liability should also have a regulatory component to improve its functioning. A conundrum presents itself, since we would have to conclude that liability law must be supplemented with regulatory requirements in order for liability to supplement regulations and, thus, to generate sufficiently specific incentives to encourage technology developers to generate additional data on specific innovative technologies and products. But maybe this is not that much of a problem, and maybe there are other approaches to the problem.

The limits inherent to the civil liability system should also be taken into account. Since liability is administered through civil litigation between private parties before courts of law, institutional and procedural limitations come into play. Courts of law have only limited authority and fact-finding is limited to what the parties to a dispute want to expose. The liability system cannot and may not usurp the role of the legislature or regulators in setting standards for economic activities. Courts of law may apply or "find" the relevant law, they may not make it. Certain conditions must be met for liability (specifically, the most common form of liability based on negligence) to work well as a system for creating *ex-ante* incentives for prevention. These conditions include that (1) the risk must be foreseeable (i.e., the causal link must be clear), (2) there must be a reasonably available option to protect against the risk (other than not engaging in the activity at all), (3) the damage that results from the activity must be unambiguous, not inherently tied to economic and social benefits, and constitute injury to legally protected interests, (4) the standard of care requiring preventive measures must be knowable (i.e., identifiable) beforehand, and (5) the question presented to the court must not be a politically charged issue with which the legislature occupies itself. In the case of asbestos-related harms to human health, these conditions were met and liability worked well, although it certainly did not prevent all asbestos-related harm. In the case of climate change and mitigation obligations, however, not all conditions are met, and liability is unlikely to generate incentives for prevention.

Risks to the environment (or environmental sustainability) present two related issues with which the liability system will have great difficulty — uncertainty and timing. If liability is supposed to prevent environmental risks that will arise only in the future, the liability system must be able to identify such risks and distinguish them from spurious risks to the environment. It is doubtful whether courts composed exclusively of lawyers, even if they have formal authority to do so, are able to sort real risks of future environmental harm from false risks and impose liability only with respect to the first. Unforeseeable risks of damage to the environment will not magically become foreseeable in civil litigation. The more remote the risks (i.e., how far into the future a possible risk will materialize), the harder it will be for the court to identify real risks, as causal links may be complex due to fundamental uncertainty, threshold issues, bioaccumulation, synergistic effects, etc. So-called "long tail" damage, which is characterized by a long time gap between the time of introduction of a technology and the manifestation of consequences, presents serious challenges to the liability system as well. If progress in risk assessment techniques results in reliable early information about future adverse consequences of emerging technology applications, it is conceivable that this information could be used successfully to expand liability's role in managing potential risks of environmental impacts of emerging technologies regimes.

In the context of ensuring the environmental sustainability of emerging technologies, the key issue may well be the foreseeability of long-term risks to the environment. These issues tend to be scientifically complex, there often is deep uncertainty about causal relations, data may be ambiguous, values come into play, and there invariably are conflicting interests, including, but not limited to, economic and environmental interests and short-term and long-term interests. For the judiciary, wading into this minefield poses normative and epistemic challenges — are the courts authorized

to weigh the conflicting interests involved, is the necessary data available, and are courts able to digest it? In the ideal world, courts would be able to incentivize companies to generate data that provide the necessary insights into the long-term impacts and consequences of emerging technologies on the environment, without discouraging incentives and imposing undue burdens on society. In the real world, courts are made up of judges that are fallible.

If no harm has arisen at the time a court is asked to impose liability, the only remedy that is able to address this possible harm is an injunction or similar court order. Before a court of law may impose an injunction, however, it must ascertain that (1) there is a causal link between the activity at issue and the threatened harm, and (2) the injunction or order sought will prevent the harm. Where causal links are inherently uncertain, ambiguous, and value-laden (e.g., because there are several, different ways to control the risk), courts lack the political accountability to make the necessary value judgments.

The key to ameliorating the problem may be to develop better risk management regulations (perhaps through the use of planned adaptive regulation) and better liability rules and systems. In particular, the interaction between the regulations and liability should be improved, not to create the perfect system, but to address shortcomings and make some improvements. Predictability is an important element of a liability regime, and it can be improved in a number of ways, including better training of judges in the sciences. Moreover, as we have seen, there are other elements of liability law that can be adjusted and improved to provide for better incentives to generate data and manage risks of emerging technologies. Legislature can create additional strict liability regimes, which eliminate the requirement to demonstrate fault on the part of the defendant. Because liability creates incentives and disincentives, however, it is important that a balance is kept, the rules are reasonable, and their application in specific cases is as predictable as feasible.

There is no holy grail. The liability system can be adjusted to improve the management of the risks of emerging technologies, while not discouraging desirable innovation. The balance is delicate, however, and adjustments are best made carefully, iteratively, and one by one, while learning from their effects and adapting the system as we go along. Legislatures, not courts, are best placed to take the lead and make the incremental changes to better equip the liability system to manage the risks of environmental impacts of emerging technologies.

Acknowledgements

IRGC would like to thank Arthur Peterson and Michael Faure for offering comments on a first draft of this paper. The views presented in this article are those of the author and are not a consensus judgement by IRGC.

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