Zeitschrift für die gesamte Versicherungswissenschaft, 113 (2024) 3–4: 321 – 341
https://doi.org/10.3790/zverswiss.2024.1449801

Mitigation and Transfer of Risks: Prevention, Insurance, and Limited Liability

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Abstract

Modern society mitigates and transfers risks in a variety of ways, which range from catastrophe prevention and insurance solutions through to injustices of a minor and inconspicuous nature. We show that the measures taken depend on the uncertainty about the risks in question and involve three trade-offs: risk avoidance vs innovation; liability vs collective risk sharing; and equity vs practicable claims settlement. A number of examples, most importantly nuclear liability and the measures taken in the wake of the 9/11 terrorist attack, illustrate that fair allocation of liability is somewhat impaired when a risk is novel or when a severe event overstrains the administrative resources. We also discuss the limits of insurance capacity, which are most relevant for pandemic risk.

Zusammenfassung

Die moderne Gesellschaft mindert und überträgt Risiken auf vielfältige Weise: von Katastrophenprävention über Versicherungslösungen bis zu kleinen, unauffälligen Ungerechtigkeiten. Wir zeigen, dass die ergriffenen Maßnahmen von der Unsicherheit der Risiken abhängen und drei Abwägungen beinhalten: Risikovermeidung gegen Innovation, Haftung gegen kollektive Risikoteilung, Gerechtigkeit gegen praktikable Schadenregulierung. Einige Beispiele, vor allem die Kernenergiehaftung und die Maßnahmen nach den Terroranschlägen vom 11. September 2001, verdeutlichen, dass eine ganz gerechte Verteilung der Haftung kaum möglich ist, wenn ein Risiko neu ist oder wenn ein schwerwiegendes Ereignis die Verwaltungsressourcen überfordert. Weiter betrachten wir Grenzen der Versicherungskapazität und ihre Relevanz speziell für das Pandemierisiko.

JEL classification: D80, G22, H12, H84, K13, K32, K41, L51, L94, O30, Q40

Keywords: Risk Transfer, Uncertainty, Polluter-Pays Principle, Limited Liability, Nuclear Liability, Insurance Capacity, 9/11

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1. Introduction

Our modern world is complex and thus highly vulnerable – to natural catastrophes, technical disasters and much more besides. But it has developed methods for dealing with catastrophic damage – or at least with the consequent economic losses – and has actually been quite successful in this respect. Insurance plays a pivotal role in this process; but the legal system and many public-sector measures also make a big contribution – one that is less visible. The basic principle is to share sudden, heavy burdens across many shoulders. This is done in quite diverse ways which, as we will see, depend on the uncertainty about the risks in question, and involve three trade-offs:

1. risk avoidance vs innovation,
2. liability vs collective risk sharing,
3. equity vs practicable claims settlement.

1.1 Objective

We want to look at risk management in a particular way, by combining two different views: while keeping an overall ethical, political, and economic perspective in mind, we focus on the specific situation of (re)insurance companies, which handle the details of many risk transfers and damage compensations. This unconventional perspective could be of interest to both academics and practitioners in insurance.

1.2 Scientific Context

A fundamental book for the overall perspective is Faure and Verheij (2007), treating environmental liability in a very wide sense. For the cultural background of the dealing with catastrophes see Walter (2008). Lahnstein (2011) combines an overall view with that of a reinsurer, inspiring our approach. For the practical aspects of risk transfer and damage compensation, we rely on a variety of sources, ranging from the insurance industry over scholarly research to diverse entities concerned with nuclear liability and other (potential) disasters, e. g. Munich Re (2001, 2012), NEA (2010, 2012, 2019), Heffron et al. (2016), Dixon and Stern (2004).

1.3 Outline

The following two sections will focus on preventive measures and on the concept of risk. Section 4 explains how risks are distributed and how certain (usually minor) injustices remain. Section 5 describes liability for accidents in nu-

clear power plants, the development of which has been highly political, and is thus a particularly interesting subject. Section 6 discusses the capacity of the global (re)insurance market. The final section is devoted to the 9/11 terrorist attacks, which despite their tragic proportions represent a positive example of risk management *after the event*.

Preliminary findings, relating in particular to the first sections and the last one, were presented in a conference paper (Fackler, 2011).

2. Prevention of Accidents

Industrialised societies invest heavily in preventing serious accidents or at least mitigating their effects (Walter, 2008). In Europe, this began centuries ago during the renaissance (Bernstein, 1996), it propelled e. g. the building of dikes and the introduction of fire protection measures. All manner of expensive rescue services are in place – including first-aid services, fire brigades and disaster control teams – as well as useful services such as snow clearing and the gritting of roads and sidewalks. The protection provided by the implementation and monitoring of technical safety standards goes largely unnoticed. Today, companies and institutions of all types have put in place their own internal risk management systems so as to be able to cope better with threatening situations, whether they be stock market crashes or computer network outages.

Since all this cannot prevent accidents from happening altogether, additional measures are taken to at least dampen their financial repercussions. A traditional preventive measure is to build up financial reserves. However, insurance companies, which specialise in covering all kinds of loss and damage, have been around for centuries, too – as have reinsurance companies, see e. g. Section 1.1. of Schwepcke (2004). Insurance companies operate within a comprehensive legal and regulatory framework that in many ways offers those who take out insurance a measure of security – it includes, for instance, minimum capital requirements for insurers, agreed standards for insurance policies, and – last but not least – legal options for enforcing insurance claims. People are encouraged – and sometimes even compelled – to make provision against risks. A recent example is the obligation to take out private health insurance cover, which is being hotly debated in the U.S., and even in risk-averse Germany was not introduced until 2009. By contrast, motor liability insurance has long been mandatory in most industrialised countries; in many cases, too, fire insurance cover for buildings is compulsory, as is workers' compensation insurance (Lahnstein, 2011).

Taxes, social security contributions and insurance are undoubtedly quite effective (at least fairly cost-effective) instruments for transferring risk: money is collected from the majority and used to prevent – or mitigate the effects of – losses and damage suffered by a minority.

3. Types of Risk

Prevention functions even better when you know exactly what risks you can expect to encounter. Many different types of risk can be distinguished (Spiegelhalter and Riesch, 2011). Here are two extreme examples:

Known unknowns: The effects of serious events and their probability of occurrence are known; but it is not known when the events will occur. In principle, that is the same uncertainty inherent in a toss of the dice. One example is the earthquake risk in regions that have been thoroughly examined in terms of seismic activity and where the location and quality of the buildings in the region are well known. Of course, a severe earthquake is still a threat, but systematic precautions can be taken against it, emergency plans can be drawn up and tested, fair insurance premiums can be calculated and charged, etc.

Unknown unknowns: One can only vaguely imagine what a serious event might be like and what its probability is. That is the case with expeditions into uncharted territory and with emerging risks (maybe due to brand new technologies), but also, for example, in regions where a volcano has become active again after being dormant for 10000 years. It is much more difficult to prepare for risks like these and, at the same time, there is the latent fear of doing either far too little or far too much in the way of prevention. This two-fold fear could recently be observed in the debates about which measures would be adequate to contain the Covid-19 pandemic.

This differentiation of risks is both modern and old. The nowadays very popular alternative terms used for the two situations described above – *risk* and *uncertainty* – were introduced hundred years ago (Knight, 1921); the instructive variant *small worlds* vs *large worlds* was suggested a few decades later (Savage, 1954).

In reality, risks usually lie somewhere between these two extremes, even though they are often clearly closer to one end of the spectrum or the other. When, for instance, a certain type of insurance is offered in a country for the very first time, that tends to be an unknown unknown for the insurer, and setting the premium for it is a thankless task. A recent example is cyber insurance, which must still be considered novel and somewhat uncertain. Years later, when the insurance product is in widespread use, the insurer has amassed comprehensive claims statistics and has no trouble in calculating the premium – the risk has thus moved in the direction of a known unknown, with minor uncertainty remaining as to the size and probability of claims.

The wide availability of insurance cover is in fact a good indicator of whether a risk is *known* rather than *unknown*, or that its classification has changed. Loss or damage suffered in a war, for example, is generally uninsurable because it is effectively impossible to calculate its scope and probability, let alone the accumulation risk. In the case of damage due to terrorism, on the other hand, there

are now signs that it is becoming insurable, even though such insurance has often been supported by the government (Michel-Kerjan and Pedell, 2005) – as is the case with the British public-private partnership *Pool Re* (Hartwig et al., 2020) and with the German specialty insurer *Extremus*, whose cover capacity of €2.5 billion is extended by about €6 billion through government support (WTW, 2020). (It may sound cynical, but the more experience we gain with acts of terrorism, the easier it is to assess the risks involved.) Conversely, as a result of the high incidence of severe hurricanes in Florida in the past decades, insurers are no longer convinced that the loss frequencies observed throughout much of the 20th century still apply. As a result, this risk is tending to become uninsurable. The public sector (i. e. society as a whole) has had to assume part of the risk through the publicly funded *Citizens Property Insurance Corporation* for those properties that can no longer find cover on the private market (Kaminski, 2006).

See Table 1 for an overview of terminology.

Table 1

Risk terminology

Randomness, known odds	**Randomness, unspecified**
Known unknown	Unknown unknown
Risk	Uncertainty
Small worlds	Large worlds
Insurable	Uninsurable

4. Restrictions on Liability and the "Polluter-Pays Principle"

Modern liberal societies have a special problem with unknown unknowns because the goal of such societies is constant progress. When they introduce innovations, they regularly take risks that are initially difficult to assess (Walter, 2008). There is a trade-off between innovation and risk avoidance, and whenever a decision is taken on whether or not to try out something new (and potentially dangerous), the question of responsibility or liability is immediately raised.

In a nation under the rule of law, responsibility is largely deemed to be as follows: anyone causing damage must make good that damage or, if that is impossible, at least pay financial compensation (a paramount example of this is the *polluter-pays principle* for environmental damage). So, if someone introduces an innovation and, in the process, causes loss or damage, they should be fully liable for the consequences.

As many examples from history demonstrate, this ideal can hardly be upheld in practice (Faure and Verheij, 2007). If people who want to try out something completely new were to be burdened with full liability for this unknown unknown, they would give up their projects altogether. To ensure that people remain willing to try out promising innovations, society must shoulder part of the risk incurred by the innovators.

Sometimes this is done quite consciously, such as in the case of nuclear energy (more on which in the next section). Many countries consider this technology to be of "national importance" and have favoured its growth by means of the statutory transfer of liability to the public sector. However, in many other areas, in particular where environmental damage is concerned, the damage potential was often underestimated (or simply ignored): only after a major loss occurred, and public pressure increased as a result, were regulations introduced along the lines of the polluter-pays principle. Another, often crucial, factor is whether industry – and the legal system – are still developing or already well established (Lahnstein, 2011). Many of today's emerging economies, for instance, are repeating (but at a faster pace) the unfortunate early history of industrialisation despite the fact that the negative experiences of the industrialised countries are so well known: initially lax standards for protecting the environment and workers, subsequently many accidents and enormous suffering on the part of the victims, followed by the gradual tightening of regulations.

Initial openness to technology (or an ignorance of the risks it poses) does not always prevail, however, as the example of agro genetic engineering in Europe shows. In the early phases of this technology's development, the political debate was dominated by worst-case scenarios. Then, the liability regulations were relaxed before being made extraordinarily strict again (Munich Re, 2001).

In the commercial world, there are many limitations of liability that (to a minor extent) run counter to the polluter-pays principle, but which have nevertheless proved themselves in practice. It is not so much about potential accidents but has more to do with normal economic activities that can result in major financial losses. A case in point is the limited liability company, the purpose of which is to cap the risk of financial loss on the part of the company's owners (thus passing on the loss, at least in part, to the company's business partners). Corporations are, in principle, investments without the obligation to provide additional capital, i. e. the investors' risk is limited to the amounts of their respective investments. And then there is the insolvency process, which relieves both companies and individuals of the burden of a lifetime of debt. In all these cases, the creditors bear a portion of the risk.

In the opinion of many economists, limited liability is a cornerstone of our modern economic system and made many key investments and innovations possible in the first place (Sinn, 2010). From the standpoint of the polluter-pays

principle, limited liability is not ideal, but the business partners of market players with limited liability are aware of the risk and are called upon to choose carefully with whom they do business.

Yet the situation is radically different with accidents, such as chemical spills in factories. Accidents of this kind have repercussions not only for the factory owners and possibly their business partners, but also for ordinary citizens who have nothing to do with the business of the factory – and who have no chance of avoiding the risk. In this case, the polluter-pays principle is desirable, i. e. ideally strict liability of the operator (who should have adequate financial reserves or take out liability insurance) and full compensation for any damage caused. Apart from fair victim compensation, internalisation of the risk of accidents through substantial liability can be motivated by economic reasons (Faure, 1995).

But such liability is not always in place, as the following example demonstrates.

5. Nuclear Liability

In many countries, the legislation governing liability for nuclear accidents has led to a complex system of private and public guarantees (see in the following Faure and Verheij (2007), NEA (2010)), although discernible efforts are being made to reduce public liability at the expense of the plant operators.

5.1 Germany

Let us first take a look at the situation in Germany. Despite the country's nuclear phase-out in spring 2023 its nuclear liability regulation is very instructive, and has anyway remained in force after the phase-out. The *German Nuclear Energy Act* (F.R.Germany, 2022) is a shining example of how operators of a new technology are initially freed from liability, making it possible for them to tackle innovation and its attendant risks. The law sets out the liability of nuclear plant operators and how they are to insure themselves. It was first drafted in 1959, a time of euphoria for technology, and was thus very favourable for the energy companies (as were corresponding laws in other countries). As nuclear energy became established, however, the law was revised several times and made more stringent. The status quo in the mid 2020s is as follows:

- Strict liability applies. In principle it is unlimited – but only since 1985.
- Liability is channeled exclusively to the operator, which exempts suppliers – and frees victims from having to sue several parties for compensation.
- Every operator must take out liability insurance with a limit of indemnity of € 256 million (equivalent to the DM 500 million originally mentioned in the

law). Cover of this type is provided by nuclear insurance pools – consortia of insurers that have been set up in many countries, primarily to insure the respective country's nuclear power plants (Faure, 1995).

- Any damage in excess of the above amount, up to €2.5 billion, has been covered – since 2002 – through a solidarity agreement between the (then) four nuclear plant operators in Germany (E.ON, RWE, EnBW, and Vattenfall Europe). Under the solidarity agreement, the four utilities have undertaken to support each other and must back their liability with corresponding assets.
- Amounts in excess of €2.5 billion are borne by each operator individually. That is termed *self-insurance*.

In the notation of reinsurers and industrial insurers (see e. g. Sections 3.3.3 and 4.2.4.2 of Schwepcke (2004) or Chapter 3 of Parodi (2014)), this form of "layered" insurance cover would be expressed as given in Table 2, where "xs" means in excess of.

Table 2

Nuclear liability layers in € billions, Germany

0.256	xs	0	**Insurance**
2.244	xs	0.256	**Operators' "pool"**
unlimited	xs	2.5	**Self-insured by operator**

For some time, the government explicitly shouldered part of the liability via a 0.5 xs 2.5 layer. However, following revision of the law in 2012, this was combined with the top layer that each operator must guarantee itself. As far as this layer is concerned, the decisive question is whether such large amounts of damage are conceivable at all. What would a major nuclear accident in Germany (or in other areas having similar population density and accumulation of assets) cost? Although projections of this type can never be truly precise, serious studies carried out by physicists and economists for, among others, the German government put the figure at somewhere between about €500 billion and €5 trillion (!), see Günther et al. (2011), Heffron et al. (2016), Faure (1995). That is more than a hundred (or thousand, respectively) times the figure covered by insurance and the solidarity agreement together. Such figures are not excessively pessimistic, as the the estimates of the total cost for the major – but not worst-case (White, 2021) – nuclear accident at Fukushima in March 2011 illustrate, which are in the range of several hundred billion euros (Kobayashi et al., 2019). These estimates are still rough and rising; decommissioning of the power plant and clean-up will take further decades.

Thus, the level of insurance set down in the German Nuclear Energy Act can be deemed adequate only if one believes there was absolutely no possibility of a serious or major accident occurring at a German nuclear power plant. By way of comparison: when it became apparent that, nowadays, the cost of caring for a person who has been severely disabled by a car accident could, in extreme cases, be as high as several million euros, the minimum limit of indemnity for personal injury in motor liability insurance in Germany was raised in 2007 to €7.5 million, an amount that is hardly ever exceeded. The purpose was not so much to protect the person who caused the accident against financial ruin, but to protect the victims of road accidents – accident victims should not need to fight long battles to gain compensation for their injuries, and adequate compulsory insurance cover is the best way of ensuring that (Lahnstein, 2011). The same motivation has led to EU directives enforcing minimum amounts covered by compulsory motor liability insurance (EU, 2009).

Despite increasingly stringent laws, therefore, the protection afforded victims of nuclear accidents in Germany – provided one considers a serious or major accident a possibility – has been much worse than that afforded victims of road accidents. The reason is clear: in spite of their financial strength, energy companies are simply not in a position to pay liability claims for hundreds of billions of euros. That would bankrupt them, and the victims would be left on their own with their damage and injuries unless the government were prepared to step in and help them.

5.2 International Standards

And yet, in Germany, the liability of nuclear plant operators and the protection against nuclear damage granted to citizens through insurance cover, etc. has been very high by international standards; for a brief world-wide overview see NEA (2019). Only very few countries have introduced unlimited operator liability at all; in most cases it is limited. As for the operators' limits of liability, most are well below the figure of €2.5 billion that can be relied on in Germany (Layers 1 and 2) – liability for anything above the operators' limits rests solely with the government. By way of orientation: the international treaties on nuclear energy liability for decades demanded only that plant operators bear a share of about €6 million in the total amount of liability – that equates to the minimum amount of liability from the early days of the nuclear power industry. In the wake of the Chernobyl disaster in 1986, there was a push toward much more stringent liability, and in Europe a minimum liability amount of €700 million for operators was agreed (after many years of negotiations). However, the corresponding treaty (Paris Convention on Nuclear Third Party Liability, 2004 Protocol) became in force only in 2022, after synchronised ratification by most West-

ern and Southern European countries (WNN, 2021). The 2004 Protocol leads to a layered public-private allocation of the liability as given in Table 3 (Heffron et al., 2016).

Table 3

Nuclear liability layers in € billions, 2004 Protocol

0.7	xs	0	**Operator**
0.5	xs	0.7	**Country of plant**
0.3	xs	1.2	**Pool of signatory countries**
unlimited	xs	1.5	**Nil**

Higher limits at national level are possible. E.g., the UK government decided to pass its guarantee (the second layer) stepwise to the respective operators, which will thus ultimately be liable up to € 1.2 billion (Borovas et al., 2016); Switzerland recently established a (largely private) insurance solution up to the same limit.

Some countries had been trying for some time to implement the €700 million limit for the operator's liability at national level, and the legislative processes seem to have gathered pace since the 2011 Fukushima accident. By the way: in many countries, including Japan, nuclear plant operators are not liable for damage caused either by severe natural catastrophes or by acts of war / insurrection. However, the Japanese government did not regard the earthquake and tsunami causing the core-melt accident as exceptional enough to exempt TEPCO, the nuclear operator in charge, from liability (NEA, 2012).

In spite of some improvements over time, the situation of the individual citizen is very unfavourable in that it is virtually impossible to purchase private cover: damage caused by nuclear power has traditionally been excluded from insurance policies. Like war, it is considered to be uninsurable, so that only the (still meagre) cover offered by the national atomic energy act remains. In the event of a catastrophe, therefore, a large part of the damage would have to be borne by the victims themselves (or by society as a whole).

5.3 USA

The United States is a special case when it comes to liability for nuclear damage. There, under the *Price-Anderson Act*, a purely private-sector insurance pool was set up with enormous coverage (Heffron et al., 2016). As in Germany, this

pool enhances the (low) amounts of cover available in the insurance market. The total amount guaranteed by this pool, in which all nuclear plant operators participate, is geared to the number of plants in operation and is currently (mid 2020s) in the range of U.S.$ 13 billion (NEA, 2019). At the same time, this represents the limit of the operators' liability; any damage exceeding that amount would have to be borne by the government. So, this set-up is at once stronger (high liability of the pool) and weaker (limited operator liability) than its German counterpart. See the overview in Table 4.

Table 4

Nuclear liability layers in U.S.$ billions, USA

0.45	xs	0	**Insurance**
ca. 13	xs	0.45	**Operators' pool**
unlimited	xs	ca. 13.4	**At discretion of Congress**

Although the differences between countries are great, all countries that use nuclear power are similar in that the loss potential in regions with high population density and high concentrations of assets is far in excess of the liability cover in place (Lelieveld et al., 2012). Further, empirical evidence indicates that, despite improved technical standards, the likelihood of severe and major accidents may be higher than the nuclear industry claims (Rose and Sweeting, 2016). Even though this glaring disparity may give us cause for concern or even anger – indeed, calls for a massive extension of liability and respective insurance are regularly heard in industrialised countries – the problem should not be viewed from the standpoint of the national economy or consumers alone.

6. Insurance Capacity

If one wants to transfer risks to the private sector, the capabilities and needs of the latter must be taken into account. New business generated by consumer-friendly liability legislation or mandatory insurance can harbour particular problems for the insurance industry, which can often be overcome (Lahnstein, 2011), but in other cases are not. A number of countries, for instance, initially introduced government-regulated, consumer-friendly (in other words: far too low) motor liability premiums; and in health insurance, in particular, parameters that are difficult to forecast – and may change depending on the political mood – can sometimes lead to huge economic and management challenges. In short, politically set conditions can make insurance premium calculation difficult (and costly), and may make it impossible to enforce these premiums.

Even where economic and operational concerns are adequately addressed, the creative will is hampered from other directions: although the financial strength of the international (re)insurance industry is huge, it cannot simply provide cover up to any amount, not even in cases where the probability of loss can be reliably calculated and more-than-adequate premiums charged. It is certainly no coincidence that, worldwide and across all lines of insurance, hardly any covers can be found with a capacity of substantially more than €10 billion per loss event. Apart from the above-mentioned U.S. nuclear liability "insurance" pool (with a capacity of around U.S.$ 13 billion), the earthquake reinsurance program of Japan's biggest mutual insurer *Zenkyoren* is an example of such a cover. With comparable capacity of around U.S.$12 billion per loss event, it is considered to be the biggest property catastrophe cover in the world (IQ, 2011). (It must be noted that Japan has a still larger program of earthquake reinsurance layers protecting a pool of insurers, but the bulk of the capacity is provided by the government (GIROJ, 2014)). But even much lower amounts of liability are traditionally carved up into smaller parcels and distributed among a large number of (re)insurers so that each risk carrier's potential maximum loss remains manageable. Thus, cover amounts in the vicinity of hundreds of billions of U.S.$ or euros, let alone a trillion, would doubtless require the participation of countless numbers of risk carriers in the financial markets and extend far beyond the scope of the insurance industry. This was indeed proposed long ago for nuclear liability (Tyran and Zweifel, 1993).

In spite of the difficulties that systemic change always poses, a society should regularly ask itself whether certain technologies are not already so established and well-understood that their operators could be expected to shoulder a greater share of the liability they give rise to, that the rules could be changed to favour the victims, and thus – in line with the polluter-pays principle – more equity could be achieved. This is in fact happening, but progress is rather slow – not just in the case of nuclear power. From liability for medical malpractice through to the environmental damage caused by oil drilling, there are many areas in which the prescribed limits of indemnity bear no relation to the potential loss amounts. This was evident in the *Deepwater Horizon* catastrophe in April 2010. As a result of the low – or complete lack of – insurance cover of the oil companies involved, the insurance industry's estimated contribution of U.S.$ 5 billion covers only a fraction of the total damage, see Lowe et al. (2010), Heffron et al. (2016). Dealing with the "remainder" of the bill was a huge financial challenge for the companies that caused the damage. Alongside such spectacular cases as this one, there are numerous examples of accidents that are by no means "worst case" and yet are still too big for existing insurance covers. In these cases, no one can claim there is a lack of capacity in the insurance market because the amounts in question can generally be placed without any problem (provided that adequate premium rates can be charged).

6.1 Pandemic Insurance

Let us finally discuss a risk having an even higher loss potential than nuclear disasters: pandemic risk, see in the following Hartwig et al. (2020), Hartwig and Gordon (2020), AAE (2021), Gründl et al. (2021). In 2020 the Covid-19 pandemic reduced the world GDP (in the late 2010s about € 80 trillion) by about 4 percent (estimates vary much). If such a reduction persists for more than a year, it well exceeds even the €5 trillion estimated most conservatively for a major nuclear disaster. A falling GDP means reduced revenue of enterprises, here caused partly by government intervention (imposing in particular social distancing), much of which in principle could be (and sometimes is) insured by non-damage business interruption (NDBI) policies.

While the pandemic was still ongoing, in the political sphere an idea emerged: widespread pandemic BI protection by private insurance, maybe via some public-private partnership. Albeit in principle being a big business opportunity, this initiative was not met with enthusiasm by the insurance industry: while Covid-19, the sole severe pandemic observed in hundred years, is far from sufficient a basis for a sound premium calculation, it gives enough insights to substantiate that, in today's highly networked society, pandemic BI policies would be triggered very much in parallel world-wide, plus correlation with other insurance (life, health, workers' compensation and certain other liability business) and with capital market losses. Even excessive premiums would not enable insurers to build up enough capital to withstand such an accumulation loss unless they limited their sales to some niche products or ceded most of the risk to the public sector.

And if it were possible to build up such capital, where could it be stored in order to be quickly available? BI claims can be expected to be paid much more quickly than large complex liability claims, so one needs liquid assets like stocks and bonds. However, the global stock and bond markets are not unlimited: at present (mid 2020s) both have about the same size as the world GDP. What would happen to these markets if 4 percent of their assets had to be liquidated within a year, plus similar figures in the following years, to pay out pandemic insurance claims?

7. The World Trade Center Loss

This paper will conclude by showing how, even after a catastrophe has occurred, measures can be taken to share the burden more effectively across many shoulders. The case in point is the 9/11 terrorist attack. It is a remarkable case of risk mitigation "after the event"; see in the following Dixon and Stern (2004). As we will see, the measures taken were successful in two ways, containing both the

overall cost and the overall anger (neither of which was achieved during the Covid-19 pandemic).

On September 11, 2001, terrorists hijacked four airliners, using them as weapons to destroy New York's two tallest skyscrapers as well as other buildings in the city's financial district, and to cause serious damage to the Pentagon in Washington. (The fourth aircraft crashed before reaching its target.) A total of 3000 people were killed (some 400 of them rescue workers, police, and helpers) and 250 were seriously injured. Many of the victims were highly paid employees in the financial services industry, and a good 60 % of them were married – facts of relevance for the level of compensation.

The insured loss across all lines of insurance – from buildings insurance through to life insurance – amounted to around U.S.$ 32 – 40 billion (there is wide variation in the published figures). In the wake of the attack, estimates of the economic damage were exorbitant, ranging as high as U.S.$ 1000 billion, though it must be said that the financial losses in the capital markets in the weeks following the attack were included in that amount.

Survivors of the attack and the dependents of those who perished, had access to four sources of compensation (which were not mutually exclusive):

- their own insurance covers;
- the tort system (suing those responsible for damages);
- government programs;
- charity.

The list of those potentially responsible for the attack – and thus potentially suable – was long:

- airlines (United Airlines, American Airlines);
- airports;
- security firms (responsible for security checks at airports);
- the authorities, the City of New York;
- police and fire brigade;
- Motorola;
- terrorist groups;
- members of the Saudi-Arabian government (as the alleged financial backers of terrorist groups);
- …

Attention focused on Motorola because it was alleged that faulty handheld radios manufactured by the company had led to the deaths of firefighters. That even rescuers and helpers could be sued was deemed a real possibility as that

had occurred in the U.S. in the past after severe losses, especially after the liability cover of the responsible parties had been used up.

The measures taken by U.S. politicians to cope with the loss were unorthodox, to say the least. (This will become clearer in the following.) However, they are an impressive example of a society's ability to take action in the face of a severe crisis.

7.1 Ensuring the Survival of Institutions

The U.S. Congress passed the *Air Transportation Safety and Stabilization Act* (ATSSA) in order to settle the World Trade Center (WTC) loss. It came into force a mere 11 (!) days after the attack and comprised the following provisions:

- Exclusive jurisdiction was granted to the U.S. District Court for the Southern District of New York for all cases related to the terrorist attacks of 9/11. This was intended to prevent the victims from filing suits in other, potentially more plaintiff-friendly, jurisdictions. Known as *forum shopping*, this is a popular strategy in America's federal, highly heterogeneous judicial system.
- The liability of many U.S. institutions was retroactively (!) capped at an amount corresponding to each institution's existing liability insurance cover. In the case of the two airlines, that figure was U.S.$ 1.5 billion each, while the City of New York's liability was limited to U.S.$ 350 million. Similar limits were imposed for the *New York Port Authority* (which administers key municipal facilities such as airports and, at that time, managed the WTC site, too) and for other authorities. Clearly, this kind of retroactive amendment of the law must, in legal terms, be considered at the very least unusual.
- Tax breaks were introduced for the victims.
- A separate fund was set up for the victims, the *Victims Compensation Fund* (VCF); see the following subsection.

7.2 Channeling of Benefits

The task of the VCF was to compensate the victims in accordance with a standardised procedure – quickly, generously and without a lot of red tape. Although they were not compelled to settle their claims via the VCF, there were incentives to do so – although conditions were imposed as well. The details of the process were as follows:

- It was guaranteed that the claims would be processed within three years (which is much faster than if the victims had sought compensation through long, drawn-out legal battles).

- The compensation was paid on the basis of presumed future income lost by the surviving dependents or injured persons as a result of the attack. While this type of damages is customary, under the VCF the onus of proof was more relaxed than in court proceedings.
- In the case of very high incomes, restrictions were imposed or the onus of proof was made more stringent.
- Awards for *noneconomic loss* were capped (and were lower than what the plaintiffs could have stood to receive in a court case).
- The majority of insurance benefits received by the victims (life insurance, workers' compensation insurance, etc.) were deducted from their VCF compensation. That is not in accordance with common legal practice. Such deductions would typically not be allowed because it disadvantages those who took precautions in the past and paid high insurance premiums and favours those who gave no thought to insuring themselves.
- No *punitive damages* were paid. (These are damages going far beyond the actual amount requiring compensation and are customary in the U.S. legal system.)
- A condition of participation in the VCF compensation process was the waiver of any legal actions for damages in respect of the attack against U.S. institutions or companies.

7.3 Creation of an Atmosphere of Solidarity and Patriotism

The (re)insurance industry waited with bated breath to see how the WTC loss would be settled. Long experience with large and complex losses had taught them that catastrophes involving many parties are not least an organisational challenge, which contributes to what is called *post-loss amplification* of the overall cost. In particular, the industry's fear was that adverse selection would prevail, i. e. only those victims would settle via the VCF who could expect to receive similar or higher benefits from the fund than they would if they sued in an ordinary court. Top-earners and victims with higher insurance claims were expected to opt for litigation and fight long battles for their high claims, further augmented by punitive damages. (Given the mood of hysteria in the country at that time, it seemed plausible that some judges would want to set an example, awarding exorbitant damages against those who had so lamentably "failed" in preventing the terrorist attacks.)

The result would have been an avalanche of legal proceedings lasting years, coupled with constant negative press. In the final analysis, that would have led to a process of social self-destruction with economic consequences far beyond the liability claims payable.

That did not happen, however. The VCF was a resounding success. Of the families affected by the disaster, 97 % opted for the VCF process and have long since received final compensation. Only 70 families decided on litigation, and thus on years of legal proceedings with relatively low chances of success. The VCF has paid out a total U.S.$ 5.6 billion to "civilian" victims (i. e. not to police or rescue workers). What is more, the victims received about U.S.$1 billion under their life insurance policies and a further U.S.$1 billion under their workers' compensation policies; by deducting insurance benefits from the compensation it paid, the VCF thus reduced its financial burden by about U.S.$2 billion. Together with money from charities and smaller government programs, the civilian victims that participated in the VCF process have received a total U.S.$8.7 billion, an average of three million per person. See the overview in Table 5.

Table 5

9/11 civilian victim compensation in U.S.$ billions

Source	**Amount**
Life insurance	1.0
Workers' compensation	1.0
VCF	5.6
Other public	0.4
Charity	0.7
Total	**8.7**

On top of this is the U.S.$ 1.9 billion that the VCF paid to police and rescue workers. For the sake of completeness, it should be mentioned that the compensation process for this latter group, including those involved in clean-up operations afterwards, did not go smoothly. There were lengthy disputes, and the situation was complicated by countless cases of injury that were not recognised until well after the event and which were difficult to assess, e. g. because they could have been caused by dust particles at the Ground Zero site. A full ten years after the attack, the dispute was still the subject of regular reports in the press; that is how long it took to resolve key issues and for the government to award further high compensation amounts.

Now that verdicts have been reached in the court cases of the 70 plaintiffs, it is possible to compare their awards with the compensation paid by the VCF. The average award per successful court case amounted to around U.S.$ 7 million, including punitive damages (Munich Re, 2012). Although that is substantially

more than the VCF average, after ten years of uncertainty and legal battles, and after deduction of legal fees, the litigation path cannot, in retrospect, be deemed to have been lucrative, especially when you consider that the families who opted for it would probably have received above-average compensation from the VCF anyway. In any case, the total amount extracted through litigation was small in comparison with the VCF pay-out.

Why did so few of the victims reject the VCF? True, the conditions it was offering were not unattractive, and the other provisions of the ATSSA made success through litigation less likely. But when you consider how litigious U.S. citizens are in general, it is astonishing that the widespread anger in the country after the terrorist attacks – which was directed not only at the terrorists themselves, but also at the negligence of the country's own institutions – did not trigger an avalanche of lawsuits.

It seems that an atmosphere of national solidarity arose, in the face of which hardly any of the WTC victims were prepared to break ranks and gamble on getting a better award from the courts. Clever public relations work probably played a decisive role in this. E.g., the then mayor of New York, Rudy Giuliani, received numerous accolades, including Time magazine's "Person of the year 2001" award, for his behaviour in the wake of the attack (Pooley, 2001). From the very first moment, he strove to revive the spirit of the city, with patriotic lines such as: "Tomorrow New York is going to be here. And we're going to rebuild, and we're going to be stronger than we were before. … I want the people of New York to be an example to the rest of the country, and the rest of the world, that terrorism can't stop us."

All in all, we can say that, in administrative and economic terms, the United States coped well with the 9/11 attack. Even the capital markets recovered from their post-9/11 crash within a few months. From the point of view of justice or fairness, it must be conceded that fundamental legal principles were violated during the process of settling the victims' claims. But we must not lose sight of the fact that most of the victims voluntarily waived their rights.

We may presume that effective catastrophe management is sometimes to be had only at the price of uneven justice. The settlement of the World Trade Center loss will be remembered as a successful, though perhaps singular, example of how society deals with a watershed event – namely by briefly breaking its own rules.

8. Wrap Up

What can we say about the role of uncertainty and the three above-mentioned trade-offs, in the light of the examples discussed here?

1. Modern society eases *innovation*, i. e. the start of novel (and thus somewhat *uncertain*) activities, by relieving innovators of a part of the risk their activities imply. A common (but hardly visible) way to do this is *limited liability*, which is essentially a risk transfer from entrepreneurs to the rest of society.
2. In the case of nuclear liability, the risk transfer from the operator to the government is explicit. Albeit operator's *liability* and the respective insurance capacity are being slowly increased (following the *increasing experience* with the technology), the main part of nuclear risk is still *shared collectively*. The (highly political) regulation of nuclear liability has also a practical aspect: clear and simple rules, set a priori, ease *efficient* victim compensation after a major disaster.
3. The victim compensation of the 9/11 terrorist attack was regulated a posteriori instead. Here *quick* and *efficient* claims settlement was the primary goal (together with keeping the overall cost down). This came at the price of compromises in terms of *equity*.

Overall, we can conclude that emerging risks (due to innovations, for instance) and the inherent uncertainty call initially for collective risk sharing, while growing experience with activities/technologies reduces uncertainty and enlarges the room for fair allocation of liability and corresponding insurance solutions. In the case of severe catastrophes, though, the strive for justice can overstrain the administrative resources, such that victim compensation must be somewhat "simplified", both within and beyond existing insurance covers. For the most severe catastrophes, independently of the inherent uncertainty, the sheer impossibility of building up the respective financial reserves may make it impossible to provide full insurance.

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