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FUKUSHIMA AND THE LIMITS OF RISK ANALYSIS

Risk analyses serve to identify future opportunities and risks systematically and thus make them calculable and manageable. Today, risk analysis is applied in an increasing number of policy fields, including in security policy. Catastrophes such as the Fukushima disaster raise questions about the limits of this approach, however. In view of difficulties regarding integration of the probability aspect, regarding risk compilation, and regarding its explanatory power, a differentiated application of the risk analysis methodology is advisable.

The Fukushima disaster raises fundamental questions about how to handle risks. Ishinomaki, Japan, 31 March 2011. *REUTERS/Carlos Barria*

The name "Fukushima" epitomises the limitations of our ability to deal with natural and technical risks. The course of events is well known: On 11 March 2011, a marine earthquake shook the Japanese islands and unleashed a tsunami that killed more than 25,000 people. Nuclear power plants were also affected by the forces of nature. In 11 installations, the quake triggered an automatic shutdown. In the Fukushima Daiichi plant, emergency power generators were supposed to cool the nuclear fuel rods. When the generators were destroyed by the tidal wave, the cooling system failed, resulting in a partial core meltdown in three of the six reactors. Once the water conduits and structural claddings had been destroyed by fire and hydrogen explosions, radioactive material escaped and irradiated the environment.

Even today, the whole extent of the catastrophe is not yet known. In particular, the long-term effects of radioactive contamination have yet to be established. By contrast, the course of the catastrophic events was investigated in detail by the Japanese government and by the International Atomic Energy Agency, as well as by public authorities in Germany and Switzerland. Legal regulations, protective construction measures, and operative crisis management processes were subjected to in-depth reviews in order to diminish the risk of similar nuclear disasters in the future.

However, the Fukushima disaster not only raises questions about the safeguards in place in Japan. It also raises overarching questions about the methodology of risk-related behaviour. What do risk analyses such as those that had informed the Fukushima installation really tell us about future hazards? Since risk analysis is used in more and more policy fields today, the methodology must be subjected to critical analysis.

Risk analysis: Purpose and method

The goal of risk analysis is to arrive at a systematic register and classification of future challenges based on a selected approach. An integral overview of all risks in one area of operations is to serve as the basis for optimal distribution of the limited resources available for dealing with them. Conceived in the private sector during the 1980s, risk analysis defined technically and econometrically is today increasingly applied in various areas of the public sector. On the one hand, risk analyses offer guidance for official actions. For instance, national risk analyses today form the basis for the content of new, future-oriented national security policies in a number of European countries. On the other hand, risk analyses also fulfil political functions. As such, they legitimise the existence and workings of actors involved in the implementation of such policies.

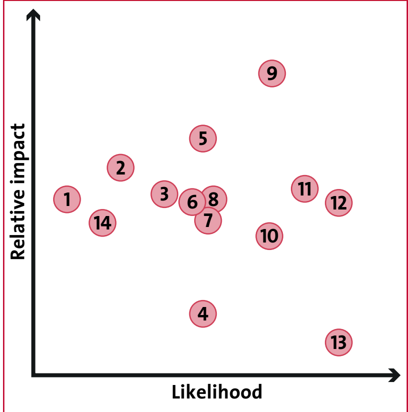
Risks are today usually assessed as the product of probability of occurrence and relative impact (risk = probability of occurrence x relative impact). This simple formula allows two-dimensional risk matrices to be drawn up. Based on such matrices, various risks are compared, ranges of tolerance are established, and priorities for risk mitigation are defined (cf. Figures 1 and 2). This seemingly elegant approach to risks is controversial, however. The construction of this risk formula has been fundamentally challenged ever since the 1980s with regard to its integration of the probability aspect. In contradistinction to the currently popular definition, certain experts categorically refute probabilistic risk analysis – they believe that the element of probability should be eliminated altogether from the formula. Other specialists accept the probabilistic element but advocate against the calculation of risk as the product of probability and impact. According to them, risks should be exclusively graded in terms of their maximum relative impact.

Probabilistic risk analysis as referential framework

These varying opinions show that the contemporary approach to risk analysis is only one of several possible perspectives on future hazards. A key characteristic of this method is that the probability factor can and should be factored in as a mitigating circumstance in the overall risk assessment – even a massively catastrophic hazard is depicted as a small risk if the likelihood of its occurrence is slight. Furthermore, the current concept is predicated on the assumption that multiple hazards can be compared based on the underlying multiplication – where unlikely, but catastrophic hazards are placed on the same level as highly likely, but moderately damaging challenges.

A referential framework thus defined has certain practical advantages when acting under conditions of uncertainty. First, taking into account the frequency of occurrence facilitates a differentiated situation report. In coastal areas, for instance, tidal flooding is a hazard, but not one to be expected on a daily basis. Secondly, it allows practical management of insecurity. The awareness that risks exist, but do not necessarily manifest themselves, facilitates a cost-conscious handling of insecurity.

UK National Risk Analysis



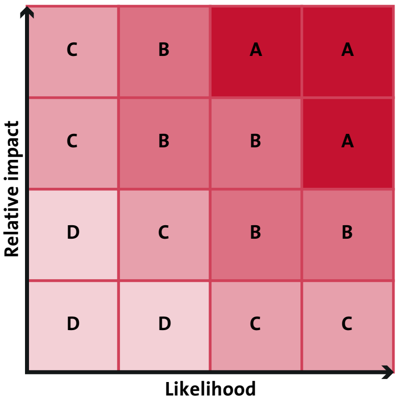
1 Major Transport Accidents
2 Major Industrial Accidents
3 Attacks on Infrastructure
4 Animal Disease
5 Coastal Flooding
6 Inland Flooding
7 Non-conventional Attacks
8 Non-Pandemic Human Disease
9 Pandemic Human Disease
10 Severe Weather
11 Attacks on Crowded Places
12 Attacks on Transport
13 Cyber Attacks: Data Confidentiality
14 Cyber Attacks: Infrastructure

Source: UK Cabinet Office, 2010 **Fig. 1**

But such a frame of reference also has its disadvantages and pitfalls. For instance, taking into account the likelihood of occurrence may excessively weaken the resulting risk assessment. As the case of Fukushima shows, this may result in catastrophic risks being taken because the probability of their occurrence is assessed as very low. Also, the equation of non-equal risks may lead to insufficiently differentiated political responses. The 1988 nuclear accident at Savannah River in the US is a good example: The subsequent investigation revealed a lack of awareness that small, but more probable hazards were more frequent and more difficult to control than large-scale, less likely hazards – although both kinds of risks had been assessed equally as products of the equation.

These discussions and examples show how the definition of risks influences our perception of hazards. The resulting framework of reference should not be accepted uncritically, as it has a decisive influence on how hazards should be conceived of in principle. But it is not only the definition of risk that must be critically questioned; the criteria for cataloguing risks empirically and the conclusions drawn from risk analyses must also be scrutinised in order to establish the limits of risk analysis.

Prioritisation of risks



A corresponds to highest priority
D corresponds to lowest priority

Source: Hagmann 2012 **Fig. 2**

The difficulty of measuring risks

In order to establish probability and impact – and thus risks –, practical research usually resorts to empirical values. The calculation of probability often proves difficult, however. Frequently, information about past events is fragmentary and too incomplete to serve as a basis for deducing regularities. Tsunami research in Japan, for instance, is based on a relative small number of historical cases. The actual calculation of probabilities is also difficult and to some extent controversial.

In the context of the current nuclear power debate, for instance, an institute in Germany calculated the likelihood of a reactor accident at 4:1,000,000 per reactor year, i.e., one accident per plant every 250,000 years. This was based on hypothetical decisionmaking processes, assumptions about possible failures, and data about reported failures. Other calculations based on the two biggest nuclear disasters to date – Chernobyl and Fukushima – take into account the world's 442 reactors and the operating years accumulated since 1971, arriving at an accident probability of 1.5:10,000, i.e., one accident every 6,667 years. This shows how uncertain the calculation of probability can be and how, due to selective expert calculations, it can result in widely discrepant results.

Gauging the relative impact also often proves to be problematic. This is also often due to a lack of reliable data. For instance, not much reliable information is so far available on the effects of the little-known Japanese tsunamis. Thus, even today, the local height of a tsunami's landfall is measured with moderate accuracy by looking at broken trees. The offsetting of various kinds of damage is also a complex exercise. Including both human losses and material damage in a single overarching damage assessment is a methodological challenge and poses an ethical conundrum. Frequently, damage assessments – and therefore the calculation of overall risk – are simply too selective. For instance, the risk analysis for Fukushima Daiichi established the risk of earthquakes and tsunamis, but neglected to take into account the costs of a possible reactor accident to the Japanese public health sector, to the fishery industry, or to tourism.

Often, risk analyses only list the internal, technical aspects of a hazard in any detail and neglect or willfully ignore the larger context. The aftermath of the *Three Mile Island* nuclear accident in the US illustrates why such an internal perspective in risk analysis is insufficient. While the accident caused no deaths, it brought about stricter regulations worldwide for the nuclear power sector, reduced output of nuclear plants, a crisis of legitimacy for nuclear power, and massive public resistance to new nuclear power stations. Grasping risks comprehensively is thus a difficult undertaking.

Limited explanatory power

The elegant formal conception of risk as the multiplication of probability and impact cannot disguise the fact that the generation of a credible risk analysis frequently poses great methodological challenges in practice. Furthermore, not only the methodology, but also the conclusions derived from an analysis must be questioned more critically than has hitherto been the case. *Statements about the future*, for instance, can only be made to a very limited extent. Risk analysis frequently rests empirically on previous events and projects their outcomes into the future. The implicit assumption that the past repeats itself with constant regularity and can be extrapolated into the future is problematic.

This becomes especially clear when fixed behavioural patterns are postulated in connection with certain hazards that are by their very nature mutable. Terrorism, for instance, constituted a significant risk in some regions in the past – but terrorist attacks, as anthropogenic challenges, need not repeat themselves regularly in the future. Even natural hazards such as earthquakes are difficult to grasp as constants, since the underlying tectonic dynamics are also subject to shifts.

Even *statements about individual cases* are only possible to a limited degree. Investigations showing that a major accident per nuclear plant is generally to be expected every 6,667 years hardly permit the formulation of statements as to the risk of an accident in an individual, specific power station. This is precisely why scientific risk research emphasises that nuclear power plants are subject to different risks according to a range of factors: Geographic location, tectonics, type of design and operation, meteorological conditions, riverine water levels, or oceanic currents generate a different risk configuration for each plant. However, finding reliable data for each individual installation often proves difficult, which may occasionally lead to statements about individual cases that lack a solid foundation of data.

Safety statements, finally, contain one of the greatest danger potentials in risk analyses. Often, they claim the ability to make statements exceeding the limits of the probability function. Security is not, however, a state that can be deduced in absolute shape from a risk analysis. For instance, if the probability of a catastrophic nuclear accident is assessed at one accident per 6,667 years, this number may appear to express a low risk. However, low though it may be, this risk remains – nuclear energy is not safe in an absolute sense. The feasibility of time-related safety statements is also very restricted. Even though an expression such as 1.5:10,000 years suggests a broad time span, this quotient does not mean that an accident can be excluded for the duration of this interval. The figure does not mean that a specific nuclear plant is safe at a specific point in time, for instance tomorrow morning.

The challenge of the future

Risk analyses are exemplars of the desire to grasp future challenges and make uncertainties manageable. Based on a chosen approach, they aim to calculate and arrange risk potentials systematically. As such, risk analyses represent the attempt to rationalise a fundamental epistemological problem, namely the uncertainty of the future. However, this attempt is faced with grave challenges. For instance, the selection of a specific risk definition favours a specific analytical perspective on hazards and discriminates against alternative approaches. The chosen methodology automatically integrates selected aspects in an investigative framework while simultaneously excluding others. Furthermore, as shown above, risk analyses are often based on insufficiently secure data and controversial calculation bases, or only calculate certain aspects of a greater hazard.

Limits of Risk Analysis

	Definition of risk	Risk measurement	Conclusions
Measurement	What does a specific risk method identify, what does it ignore?	How reliable is the empirical basis of a risk analysis?	What conclusions can be drawn from a risk analysis?
Limits	Danger of conceptual self-limitation of an investigation	Question of empirical reliability of an analysis	Danger of untenable statements
Best practice	Adoption of multidimensional risk approaches	Transparent presentation, expansion and update of data set	No partial or exaggerated interpretations

A combination of diverse risk approaches would allow hazards to be measured within a greater framework. In terms of the underlying data, a redoubling of efforts to increase the credibility of risk analyses might be undertaken. But ultimately, the fact remains that risks can only be experienced or known to a limited extent. Nevertheless, risk analyses are consistently mis- or overinterpreted, especially when their interpretation is subjected to the purposes of diverse interest groups. Thus, experts occasionally represent risk analyses as being more scientific than they really are; those with a strong affinity to industry may only cite partial investigations in order to promote an installation as constituting a manageable hazard even without costly security measures; or certain politicians may exaggerate or trivialise certain elements of risk analyses as it suits their political intentions.

Risk analyses are useful for dealing with the future and developing means and priorities for dealing with them already today. This endows them with a practical usefulness. A more differentiated understanding of the possibilities and limits of risk analyses is indispensable, however, if the method is to be applied responsibly. In order to avoid untenable conclusions and applications, it is necessary always to subject the conception and compilation of risks and the conclusions of a risk analysis to critical scrutiny (cf. Table). This is why risk investigations must always be conducted in a differentiated and transparent manner. Especially if large population groups are affected by possible catastrophic risks – as is the case with large-scale industrial installations – risk analyses and their conceptual underpinnings must be transparently explained and laid open.

In Switzerland, too, there is room for improvement in this respect. For instance, Swiss risk analyses in the area of nuclear energy also tend to adopt the insider perspective and do not take into account the entire scope of national and international social, ecological, and economic damage that would result from a possible accident. At the rhetorical level, too, various statements in the context of the current nuclear power debate appear to be mainly suggestive and do disservice to the goal of a sophisticated debate. This is the case, for instance, when risk analyses of nuclear power are presented as "safety analyses", although they actually refer to a danger that is not even negated, or when an installation is described in absolute terms as being protected from natural hazards, even though such risks can by definition never be completely excluded.

"Fukushima" is a byword for a human tragedy. But the catastrophe may also teach us to adopt a critical approach in dealing with risks. Ideally, in Switzerland, too, this nuclear accident should not only give rise to just another review of guidelines and safety measures, but also stimulate a more critical contemplation, a more differentiated awareness, and a better informed way of dealing with the method of risk analysis. Such a discussion ought to aim at better understanding the usefulness and the limitations of risk analysis and to enhance our awareness of the fact that a risk analysis can only ever be an attempt to systematise an uncertain future based on a chosen approach.

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