



Improving government policy on risk: Eight key principles

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ABSTRACT

This paper discusses the basic principles that a government should adopt when it comes to risk. There seems to be broad agreement about general principles, such as openness and transparency, involvement, proportionality and consistency, and making decisions based on evidence, but when it comes to a more detailed level, suitable principles are missing or are inconsistent. For example, what does it mean to base decisions on evidence or to act with proportionality when regulating or managing risk? The present paper aims at stimulating a discussion on this topic by formulating eight specific principles that governments should apply for the effective treatment of risk in society. The authors consider these eight principles to reflect current scientific knowledge produced by the risk analysis field, but like all principles of this type they are grounded in normative requirements of “good” governance. Several examples are used to illustrate the discussion.

1. Introduction

All activities are subject to risk; each of them will result in one and only one outcome, but which one we do not know today, since there are uncertainties. Hence, anticipating this outcome is a challenge. There are uncertainties about future developments, relationships between causes and effects, and context conditions [68]. Examples of such uncertainties include the performance of nuclear repositories for thousands of years, the regional distribution of climate impacts due to the increase in greenhouse gases, the spread of infectious diseases, and the type, magnitude and number of terrorist attacks. Looking, for example, at the coming year, a pandemic may or may not develop, yet we need to make decisions regarding whether it is prudent to allocate resources to prepare society for such an event. The tool for informing this decision is risk analysis. Experts assess the risk, using the knowledge they have on the topic. They make predictions of what will or might happen, but they face uncertainties. How reliable or trustworthy are these risk assessments? How much confidence can risk managers and regulators place on these assessments when they have to make decisions on how to treat these risks before they possibly materialise?

A good case in this respect is swine flu in 2003 and 2009. The WHO (World Health Organisation) declared that the flu had developed into a world epidemic, and a vaccine was hastily developed [85]. There were reasons to believe that the flu would cause serious illness and problems. To limit the epidemic, it was important to act quickly, and some governments implemented extensive public relations campaigns to get people vaccinated, despite the fact that the vaccine had not been

thoroughly tested for side effects [57]. Governments were faced with a dilemma. They had to balance the need for action, to meet the risks linked to the spread of the epidemic, and the risks related to potential side effects. Quick and extensive vaccination might control the disease and reduce damage, but it would also impose some level of risk on the population as there could be severe side effects from the vaccine. The degree to which the risks were faithfully characterised, also addressing possible unknown side effects, is open to discussion [21]. In public communication, most governments opted to advertise or even subsidise the vaccination without mentioning the potential side effects. The side-effects were not an issue in the governmental communication efforts, at least in the Nordic countries [5]. The general criterion of being open, transparent and balanced about the understanding of the nature of risks to the public suffered. The decision was difficult for the authorities because of the time pressure; they had to balance difficult judgements concerning the development of the flu, the efficiency of the vaccination, risk and uncertainty issues, as well as ethical aspects [5].

From a risk management and risk governance perspective, the case illustrates that dealing with uncertainties and ambiguities in risk management is not a trivial task. It involves serious reflection on trade-offs and conceptual thinking about the nature of proper policy guidance when it comes to decision-making in the face of risks [28]. The swine flu case relates to many key principles and features of risk management and governance, including:

- The characterisation of risk in the face of large uncertainties and ambiguities.

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- The need for proportionality and consistency in decision-making.
- The choice between various management approaches such as the cautionary and precautionary principles, and the risk-assessment approach.
- The role of risk perception in risk management.
- The best way of communicating risk.
- The trade-off between openness and transparency versus effectiveness and efficiency.

Different countries have developed different strategies and policies with respect to the issues mentioned above. There are always dilemmas, calling for a balance to be made and also compromises, as the swine flu case illustrates. Governments would like to know in advance the likely impacts of each of their decision options based on the best available science, but what does this mean in practice when we face risk and uncertainties?

An interesting concrete example showing the core elements of a governmental risk management policy is the UK document published by the House of Lords [84]. It states that, in brief, the guiding principles of governmental risk management are:

- “Openness and transparency—government will be open and transparent about its understanding of the nature of risks to the public and about the process it is following in handling them
- involvement—government will seek wide involvement of those concerned in the decision process
- proportionality and consistency—government will act proportionately and consistently in dealing with risks to the public
- evidence—government will seek to base decisions on all relevant evidence
- responsibility—government will seek to allocate responsibility for managing risks to those best placed to control them” [84].

The swine flu example shows that, in practical situations, these principles are not easily implemented. Moreover, the principles are all noble in cause but they may contradict each other in many cases or lead to ambiguities in terms of what is at stake and what is the most suitable decision option. The scientific literature covers a huge number of papers and books addressing the basic ideas and principles of risk management and governance, for example Fischhoff et al. [26], Hood et al. [36], Kirwan et al. [44], Renn [63], Aven and Renn [9] and Rosa et al. [69]. See also Hamilton et al [31,32] who argue that much of the impacts of risk management and governance is for re-allocating investments in science investigations and R&D. The main point here is to allocate a given amount of money so that safety gains can be optimised. For some canonical principles for defining risk programs, see Teng et al [81,82].

It is common to distinguish between three major strategies for managing or governing risk: risk-informed, cautionary/precautionary and discursive strategies [67]. The appropriate strategy is typically a mixture of these three. The risk-informed strategy captures the treatment of risk – avoidance, reduction, transfer and retention – by the use of risk assessments (appraisals). The cautionary/precautionary strategy introduces caution in choosing risk management options and highlights robustness and resilience, including features such as constant monitoring, containment, research to increase knowledge and the development of substitutes. In the discursive strategy, measures are implemented to build confidence and trustworthiness, through the clarification of facts, reduction of uncertainties, involvement of affected people, deliberation and accountability [63].

However, relatively little scientific work has been devoted to the challenge of formulating and discussing how these various principles and strategies interact and how they can be made operational for governments when dealing with risk. The present paper addresses this challenge, by integrating general governmental criteria as illustrated by the UK [84] policy document (see also e.g. M I & E [56] and [58]), as

well as scientific literature providing analytic arguments for how to manage and govern risk, as well as the authors’ insights on these issues obtained from both practical experiences and theoretical work. Furthermore, as all principles include normative implications the paper draws upon the well-established prescriptive foundations of “good” governance [29]. The main aim of the paper is to contribute to the improvement of governmental policies related to risk. We do this by articulating eight key principles that we consider essential for guiding the governmental management of risk. Each of these principles is thoroughly discussed, including their meaning, scope and boundaries. In addition, interactions between these principles are addressed.

We have chosen a total of eight principles that reflect our priorities in normative advice to risk managers and regulators. We do not provide explicit argumentation for why these eight principles have been chosen instead of others. Without any doubt, other analysts might have chosen other principles. Our selection is based on theoretical insight and practical experience and includes a strong normative component. A strong degree of subjectivity is unavoidable if one seeks to identify the most important principles. The present paper is not aiming at offering a comprehensive and exhaustive list of principles - the idea is rather to highlight some principles we consider essential for governments to apply for ensuring prudent risk treatment in society, on the basis of what we consider as current scientific knowledge about the topic and what reflects our experience with a variety of risk domains. The paper seeks to improve the structuring and rationale for which the current knowledge on the matter is founded. The paper builds on the authors’ previous works but refines and extends this for the present purpose.

Science is in general about knowledge generation, and the present paper aims at contributing to the risk science by conducting primarily a conceptual analysis, providing orientation, overview and justification of beliefs and perspectives related to how governments should handle risk. The work is carried out in line with well-established criteria for such research, related to issues like identification, revision, delineation, summarisation, differentiation, integration, advocating and refuting [53], and it is evaluated on the basis of aspects like originality, solidness, relevancy and usefulness (see e.g. [8]).

The principles are presented in Section 2, and followed up with a general discussion in Section 3. Finally, Section 4 provides some conclusions. Several examples are used throughout the paper to illustrate the points made.

2. Eight key principles guiding governments on how to deal with risk

In the following we will present and discuss the eight principles, which can be summarised by the following headlines:

1. In general, the proper risk level is a result of a value and evidence/knowledge-informed process, balancing different concerns. To develop values, risk taking is needed. How much risk to accept in pursuit of value is context-dependent and depending on how values are weighted.
2. This process of balancing different concerns can be supported by cost-benefit balancing methods, but this type of formal analyses needs to be supplemented with broader judgements of risk and uncertainties, as well as stakeholder involvement processes.
3. To protect values like human lives and health, and the environment, the associated risk must be judged to be sufficiently low.
4. Risk perceptions need to be incorporated into risk governance but with great care.
5. Three major strategies are needed for managing or governing risk: risk-informed, cautionary/precautionary and discursive strategies. The cautionary/precautionary strategy is also referred to as a strategy of robustness and resilience. In most cases the appropriate strategy would be a mixture of these three strategies.
6. Governments should be open and transparent about their

understanding of the nature of risks to the public and about the process they are following in handling them.

7. Governments should seek to allocate responsibility for managing risks to those best placed to control them.
8. Intervention is needed in the case of market failure or equity issues.

There is no ranking in the order of appearance of these principles; however, some of the most fundamental propositions come first.

2.1. In general the proper risk level is the result of a process balancing different concerns

In general, the proper risk level is the result of a process balancing different concerns (value generation, cost, safety, personal freedoms and civil liberties, etc.). Activities in life, industry and society are initiated and performed to obtain something of value. This is normally called benefit. Benefit describes an outcome that people value positively; this could be material or non-material goods. We build, for example, nuclear power stations for the purpose of developing energy, we invest in infrastructure to improve the transportation of people and goods, we send people to the moon to explore space, etc. However, there are always some costs – interpreted in a wide sense – associated with the activities. These costs also include risks related to the potential negative side effects of these activities. The risk is not the main driver for the realisation of the activities. Rather, risk is something, related to the activity, that we need to take into account when making decisions on whether to initiate the activity or on how to best perform the activity if realised. It must be acknowledged that generating benefits and value requires a certain degree of risk taking. Therefore, we need to compare the benefits of the activity with the costs and these risks, and then make a decision on whether the benefits outweigh the costs and risks or the costs and risks outweigh the benefits.

In a second step, we also need to decide how we can reduce the costs and risks without compromising the benefits. In the balance between benefits, costs and risks, risks are rarely taken for their own sake (only risk as a thrill); the risks are accepted or tolerated because a *positively valued service to individuals or society as a whole* is sought that provides more good than the bad linked to the associated risk [26,78].

However, the juxtaposition of benefits versus costs and risks is not straightforward. There are two major issues:

- a) The first relates to the value diversity in a plural society. The judgement about what people value as a benefit or a dis-benefit may differ from group to group and from individual to individual [73]. For example, an activity that promises to promote industrial growth will be welcomed by most economic stakeholders but may be regarded as a dis-benefit by many environmental stakeholders, fearing additional environmental degradation. Furthermore, goods are not equally distributed. A financial gain by a transaction that benefits the 1% richest people in a society may be seen as a dis-benefit by the poor (violation of equity principles), even if the poor are not worse off than before the proposed transaction (Pareto optimal solution). The question arises: who decides what outcome of an activity or decision option is framed as a benefit or a dis-benefit or something in between? Often public risk managers and regulators focus on dis-benefits where almost all members of a society agree *prima facie* that this impact is not desirable, such as an increase in mortality, morbidity or environmental degradation. It is not by chance that most risk management agencies deal with these publicly affirmed dis-benefits, as almost all members of society agree that the government has the duty to protect people from physical harm. Yet, even in those cases, differences in distribution (who will suffer the most and who will gain the most?) may impede collective decision-making rules when making trade-offs between benefits and dis-benefits.
- b) The second issue relates to the unavoidable uncertainties that are

associated with the benefits and costs. Usually, the benefits are more certain than the costs (because the activity is meant to produce these benefits). Unintended side effects of the activity, for example the production of a specific good, may occur as there are risks. Some of these risks may be anticipated, others not [14]. Loosely speaking, the less experts know about an activity or intervention and the more this activity is shaped by changing context conditions, the more likely it is that society will experience some unpleasant surprises.

In a democratic and liberal market society, a basic thesis is that the value judgement of whether the costs-risks outweigh the benefits (or vice versa) should be left to the individual decision maker, as long as this person is fully informed about the costs-risks and benefits (or at least has access to all this information), is mentally capable of making this judgement and, most importantly, the costs-risks and benefits can be limited to this individual (no major external effects). However, in practice there are nearly always some external effects [22]. In addition, what does it really mean to be fully informed about costs-risks and benefits?

Think about the costs associated with smoking. An individual decides whether or not he/she would like to smoke, but the societal costs are huge and may justify measures to stop individuals from smoking. The result is that governments intervene and regulate. In the swine flu example, each individual had to make a choice – vaccination or not – despite poor knowledge about the risks related to this activity.

In addition to individual risk taking, society is confronted with collective risk taking, for example when national security is at stake. Other activities are on the borderline between collective and individual risks, such as ensuring food safety or licensing chemicals. People trust that the government is able to control these risks, such as food poisoning, or protect individuals if ignorance or misperceptions would lead to fatal or chronic results, thus providing little opportunities for individual learning [59]. The boundary between individual responsibility for one's own actions and government's paternalistic regulation is fuzzy and depends on political convictions (right-left), political culture (libertarian versus individualistic) and historical traditions (tobacco versus soft drugs). Although it is a primary government task to protect the safety and health of its citizens, there is always a balance to be made as the above examples illustrate. Most risk decisions touch upon more than just one dimension (for example, health, environmental damage, costs, etc.). Making rational judgements on different options hence requires the assignment of tradeoffs. Tradeoffs represent manifestations of value priorities that cannot be deducted from factual information alone but require political value judgments. In a democratic society these value judgments need to be legitimised; paternalism would not suffice.

A case study about the oil industry provides a good illustration of this discussion [10]. The oil and gas industry in Norway has created huge value for Norway, but considerable risks have been taken, with respect to both investments and safety. A key principle of the governmental policy was that the state pays a main share of the investments and costs but also receives a corresponding share of the income from the production. The state was thus willing to take substantial risk in exchange for the expected benefits. It was aware that the activity also implied substantial safety risks. Many accidents have occurred over the years and about 300 persons have lost their lives. In 1981, 123 persons were killed in the capsizing of the Alexander Kielland platform and there have been several helicopter crashes, the latest in 2016 when 13 persons were killed. The benefits of the oil and gas production were considered to have such a huge potential that the activity was worth realising, despite the risks. Given the huge benefits that have actually been created for the state over the last 40 years, there are few people today that would criticise the state for taking this risk. This may be quite different from other oil-producing states such as Nigeria or Venezuela.

Today, the situation is more complex, and Norwegian society is more diversified in its value structure and concerns. The country faces a

fierce debate about the development of oil and gas fields in environmentally vulnerable areas (such as the Lofoten area). For many political parties and persons, there is much less willingness to take risks in exchange for the economic benefits than 20 years ago. Many believe that more oil development would mean doing a disservice to Norwegian society. The value of potential environmental damage has a stronger impact than the value of more economic prosperity on the judgement. Moreover, and roughly speaking, those who are economically well off judge the risks of environmental degradation more seriously than those who are at the lower end of the income distribution. The issue is also related to the overall goals of reducing CO₂ emissions. Some parties see an extension of the petroleum activities as being in conflict with these goals. It may also be true that it is easier to renounce the additional incomes induced by more oil exploration now, when the economy of the country is already strong.

Governmental policies need to find the proper balance between stimulating benefit generation and risk reduction. Some political parties and persons are willing to take higher risks in pursuit of certain benefits than others. There is, however, no value-free balancing process that is acceptable to all stakeholders. There is no objective correct governmental policy. Different approaches and methods exist for supporting these balancing processes, reflecting different stakeholder values and available evidence/knowledge. We will return to these in coming sections; see in particular Section 2.2.

This Principle 1 means that, when making their decisions, governments seek to be informed by all relevant evidence from all relevant stakeholders. Evidence here includes relevant data and information, for example accident data and statistics, as well as knowledge in terms of justified beliefs derived for instance through risk assessments. The justified beliefs can be derived on the basis of observations, reasoning, modelling, dialogue, etc.

The above discussion has made it clear that the decision-making cannot be purely evidence-based [52,54]. Evidence may cover subjective judgements and beliefs from various stakeholders; these can be more or less strong and also erroneous in some cases. The beliefs can be based on assumptions that may turn out to be wrong. Hence, decision makers also need to address these limitations and uncertainties related to the knowledge basis. In addition, there could be different values related to the various concerns, as illustrated in the above oil and gas example; to use the terminology of Renn [63], there is normative ambiguity, which could strongly influence the decision-making.

2.2. Cost-benefit type of analyses and the need for seeing beyond them to properly support the decision-making

Faced with many attributes and concerns, the decision makers would ideally like to have a method that could guide them on which alternative or measure to choose, to ensure that the resources are used in the best possible way. The literature is full of theories and approaches that seek to meet this challenge by optimising the decision-making according to such a goal. The most well-known scheme is the subjective expected utility theory, which has a strong rationale and appeal [27]. However, this approach is purely subjective and does not provide any guidance for the collective decision makers on how to use their resources in an optimal way. The approach is also difficult to use in practice, with its demanding ways of specifying probabilities and utilities [4].

Cost-benefit type of analyses are more commonly used, in particular for governmental decision-making [38,78,84]. They are attractive, as they aim to show how to best use the resources in relation to the options at hand. The analyses are well-established, standardised to a large extent and ensure traceability of the arguments used. All costs and benefits are transformed to one common unit, normally money, introducing concepts like the value of a statistical life (VSL). This value represents the amount of money the society is willing to pay to reduce the expected number of fatalities by one unit. In practice, the criterion used

for comparing options and measures is based on expected net present values, $E[NPV]$. Hence, the contribution to the expected value from an accident leading to 100 fatalities having a probability p , is taken as $100 \text{ VSL } p$. The VSL concept is controversial as thoroughly discussed in the literature, see for example Ale et al [1,2] and Aven [4], pp.120–121, see also discussion below concerning the use of expected values to support the decision making. Using a concept like VSL does not mean that one specifies the value of a life. In principle a life has an infinite value; there is no amount of money that a person would find sufficient to compensate for the loss of a daughter or son. However, a statistical life has a finite value as societal decisions need to be made that balance different concerns – benefits, costs and risks. Otherwise it would be impossible to assign any tradeoffs. The VSL is a decision-support tool for this purpose. Thus for groups of people the use of VSL numbers can be interpreted as providing indirect specifications of the value of these lives.

For one decision problem, the use of this approach will clearly not mean that the resources are used in an optimal way, as the actual outcome could deviate strongly from the expected value. This is indeed the case when there is a potential for extreme outcomes, which is a common case in relation to risk, safety and security. However, when considering many activities or projects, the associated variation and uncertainties are reduced, and the use of expected values, as in classic methods of cost-benefit analysis, becomes meaningful. In this context, it is common to refer to the portfolio theory and the law of large numbers when undertaking this type of reasoning [9]. In the ideal case, when we are considering an infinite number of similar independent situations, the law of large numbers expresses that the average project value is equal to the expectation of the value of one project. Hence, by computing the expected value for the project studied, there is justification for this value to also represent well the overall value of the portfolio.

There are two main problems with the practical use of this reasoning: the number of relevant projects is not infinite, and if the outcomes can be extreme one occurrence could affect the whole portfolio; in addition, the expectation computed is normally based on subjective (knowledge-based, judgemental) probabilities [49,79], which may correspond to a varying degree to what happens in the real world. These probabilities and the related expected values are judgements made by the analysts and may provide poor predictions of the actual quantities in real life. Hence, the expected values produced could strongly deviate from the actual values, even if we consider many projects.

The implications of these observations are that cost-benefit type of analyses based on expected values need to be used with special care [42]. They provide decision support and inform the decision makers, but it must be acknowledged that they do not give much weight to risk and uncertainties. They represent, in fact, a tool that favours development more than protection. The use of such analyses consequently must be supplemented with specific assessments and judgements of risks and uncertainties (including vulnerabilities and effects on different populations, as previously mentioned), see also discussion by Ale et al [1,2].

Hence also the common idea of using a fixed VSL number for different sectors and applications is problematic and should not be implemented (as also argued by [2]). The approach ignores specific risk and uncertainties and could seriously misguide decision-makers.

An example illustrating this discussion is the use of the ALARP (as low as reasonably practicable) principle. It is a principle introduced to give value to safety, expressing that if we have a measure that can improve safety, it should be implemented, unless one can demonstrate that the costs are in gross disproportion to the benefits gained [1,12,37]. A common way of checking the gross proportionate criterion is to use cost-benefit analysis. However, such an approach is hard to justify, as this type of analysis is expected value based and hence gives little weight to the uncertainties and the risk, which are the concerns actually intended to be met by this principle. Alternative ways of implementing the ALARP principle are therefore suggested; see for example Aven and Vinnem [12] and Aven and Renn [9]. The basic idea is

that if a cautious policy on safety is to be implemented, there is also a need to consider implementing a measure when the computed $E[NPV]$ is negative, if the measure can contribute to a reduction in risks and uncertainties and a strengthening of the robustness and resilience of relevant systems. In many cases, it is preferable to simply provide judgements of all the pros and cons of the various alternatives and measures, to compare these by means of overall qualitative judgements and to make a decision, without trying to convert all aspects into one and the same unit. Computing $E[NPV]$ in the case of large risks and uncertainties does not provide meaningful input for the decision makers. The arbitrariness is too great.

See Ale et al [1] for a recent in-depth discussion of the ALARP principle. In this paper it is argued that ALARP is not a principle at all: application of the ALARP concept may lead to different decisions in similar contexts.

In addition to the need to reflect uncertainties and risk beyond expected values, the issue a) mentioned in the previous section, concerning the value diversity in a plural society, imposes limitations for the use of cost-benefit type of analyses. More and more decisions in a complex and plural society include multiple and often contradicting values and a high level of uncertainty of the consequences of the activities. In these cases, traditional balancing of aggregate costs and benefits is neither sufficient nor politically acceptable. Plural values demand a risk governance process that starts with a major framing effort to identify the concerns, expectations and associations of major stakeholders in the debate, in order to gain an accurate picture of the benefits and dis-benefits associated with the activity. Facing uncertainty and ambiguity demands a more careful balancing approach that is not limited to comparing statistical expected values for benefits, costs and risks. It requires special consideration for uncertainty and a more cautious approach to ignorance and surprise. This will be further explained in the coming sections. See also Karvetski et al [40] and Lambert et al [48] who discuss the importance of highlighting stakeholder concerns in case of high (deep) uncertainties, and Lambert et al [47] who point to the important confluence of qualitative and quantitative information in risk governance and public policy.

It is often stated that governments should seek proportionality and consistency in decision-making [72]. These goals seem obvious and rational at a first glance: we should not use many more resources in one sector compared to others, to obtain the same level of performance. For example, it would violate these principles if costly measures were to be prioritised in one sector to reduce the risk there, even if the risk situation is much more serious in other sectors and the costs for risk-reduction are the same. Unfortunately, this principle is not easily implemented in practice. How can we compare different activities with respect to risk? There are no objective ways of characterising risk. We may compute various risk metrics, but caution must be shown in giving these indices a stronger authority than can be justified. Comparing, for example, traffic risks with nuclear power is not really possible using any type of risk metrics, as the potential for a major disaster is present in one case but not in the other [18]. Governments should be informed by risk assessments, but it is not possible to provide easy and direct comparisons across different sectors and activities. The use of cost-benefit type of analyses is a tool to ensure proportionality and consistency in decision-making but, as discussed above, this tool does not really address risk and uncertainties and can therefore not alone provide clear guidance on how to make adequate risk decisions. Hence, we recommend adherence to the goals of proportionality and consistency in decision-making by means of broad comparisons of risk characterisations and other relevant cost-benefit attributes, giving due weight to all aspects of risk, including uncertainties and strength of knowledge judgements.

2.3. To protect values like human lives and health, and the environment, the associated risk must be judged to be sufficiently low

Following the 2011 Fukushima nuclear disaster, Germany has decided to phase out their nuclear power plants by the end of 2022 [24]. There is concern about both potential nuclear accidents and nuclear waste. The risks are not considered low enough to be acceptable. This judgement of unacceptable risks can be viewed as independent from the benefits that are associated with the generation of nuclear power. Philosophers call these risks inviolate or categorical: they cannot be compensated by benefits, regardless of how plentiful they may be [39]. The risks alone are enough to ban the activity. It is interesting to note that the German Ethics Commission, which paved the way for the governmental phase-out decision, was divided on this account. Roughly half of the commission stated that nuclear energy is not acceptable because of its catastrophic potential, independent of the probability of large accidents occurring and also independent of its economic benefit to society. The other half based their decision on recommending the phase-out on a cost-risk-benefit comparison of nuclear energy with other energy-producing technologies and concluded that, under the present circumstances, other means of electricity generation were feasible with almost the same benefit but less risk than nuclear power [65].

How should governments then proceed to determine which risks should be regarded as inviolate and non-compensational? Should governments formulate explicit criteria for what are unacceptable or intolerable risk levels to protect human lives and health, and environmental values? The scientific literature on risk management often refers to such criteria, stating what should be considered as unacceptable or intolerable risk in society and for industrial activities. The benefit of using such criteria is that a clear rule can be communicated and some consistency can be ensured across different activities. In the literature, reference is commonly made to maximum limits for individual risks and limits defined by f - n curves expressing the frequency f of accidents having at least n fatalities [55].

However, in general, such criteria in the form of strict limits for maximum risk, are problematic:

Firstly, as discussed in Section 2.1, the appropriate risk level cannot be seen in isolation from other attributes and concerns, in particular the benefits of the activity. There are no universal numbers expressing what should be regarded as intolerable or unacceptable. If such criteria should be specified, they need to be determined so that they do not conflict with or hamper activities that provide a potential for major societal benefits. For this reason, many analysts suggest that such risk thresholds are defined for a set of activities that provide roughly the same benefit. For example, arguments can be provided for regulating indoor air pollution in factories so that no more than 1 in 10,000 will get cancer as a result of exposure to a chemical in the air. This is independent of the production, as long as the goods produced are considered to have roughly the same benefit. Similarly, one could set a limit related to fatalities for any kilowatt hour produced, regardless of what the fuel for the generation of the electricity may be. Such limits act as clear statements of what risk levels the governments accept or tolerate in exchange for one unit of a desired service. Producers of the respective activity would then need to focus their work on demonstrating that the risk is acceptable or tolerable, by reference to the threshold or standard prescribed by the risk regulators. There may be additional requirements in the regulations to further reduce the risk, as for example in the oil and gas industry, where the ALARP (As Low As Reasonably Practicable) principle is a legal requirement in many countries, but these are often difficult to implement as long as the absolute criteria exist. See discussion in, for example, Aven and Vinnem [12] and Khorsandi et al. [43], and Section 2.5.

If such maximum standards are defined and enacted, they need to be checked to see whether they are met or not. However, if for example probabilistic criteria are defined, as in the above examples, the

measurement issue is critical. The risk numbers derived or estimated would normally be very much dependent on the analysts and their approaches, methods and assumptions. Uncertainty is a main problem here, too. Risk is not adequately described through numbers alone, like probabilities. Essentially, risk measurements capture three dimensions (consequences, judgements of uncertainties, and knowledge basis) and, in most cases, any attempt to reduce risk judgements to one dimension will lead to poor assessments and judgements [6]. We will return to this point in Section 2.5.

So, what are we then recommending governments to do?

To make decisions about permitting an activity or not, governments need to be flexible in balancing different concerns. Overall qualitative objectives that reflect the concerns of the major stakeholders may be formulated to highlight areas that should be given special attention and priority, but strict criteria in the form of general thresholds for risk (un)acceptability across a variety of activities will reduce the necessary flexibility, will not give adequate justice to each situation, may cover or conceal important aspects of risk and uncertainties, and will experience major acceptance problems by those affected.

In particular, risks that are regarded as inviolate and non-compensational should not be linked to a specific numerical threshold, for example the maximum number of people killed in an accident. Such judgements also depend on the preferences and perceptions of those who make the risk decisions or are affected by them. In the aftermath of the Fukushima accident, Germany opted for phase-out, while the United Kingdom opted for nuclear energy expansion.

Broad risk assessments are needed to inform decision makers. Risk assessment results should be evaluated with the purpose of informing decision makers rather than concluding on a finite judgement about unacceptability, intolerability, etc. [30]. Typical risk numbers for similar activities to the one studied can be informative and used as a basis for comparisons, while acknowledging the need to see them in the proper context, taking into account uncertainties, strength of knowledge, supporting evidence and choice of assumptions, etc. Sometimes, if the environments are quite similar, it may help to have the same standards for all situations in order to demonstrate consistency and fairness. Yet, such an approach needs to be implemented with care; deliberation processes are needed, not automatic rules that are intended to fit all situations [63].

2.4. Risk perceptions need to be incorporated into risk governance but with great care

The literature on risk perception has demonstrated that mean values of the perceived seriousness of risks often deviate from mean or medium expert judgements or assessments of the same risks [15,63,74,75]. Politicians are hence facing a dilemma: if they base their risk policies on the expert judgements alone, they may lose public support; if they take the perceptions as guidance for their decisions, they are likely to spend their resources dedicated to risk reduction unwisely. They may finance costly risk reduction measures that are high on the public agenda but may only marginally improve human health and the environment, and they may not address serious risks because these are not perceived as serious in the public eye. It is evident that, from a normative perspective, knowledge about individual perceptions of risk cannot be translated directly into risk-reduction policies. Given the many insights, from psychological research, into the fact that perceptions are based partially on biases or ignorance, it does not seem wise to use them as yardsticks for risk reduction [9,26,76,86]. In addition, risk perceptions vary among individuals and groups: whose perceptions should be used to make decisions on risk?

At the same time, however, these perceptions reflect the real concerns of people and include the undesirable effects that ‘technical’ analyses of risk often miss. It is true that laypeople’s views of risk are intuitive and less formal and precise than experts’ statements. However, as Paul Slovic observed, “Their basic conceptualisation of risk is much

richer than that of experts and reflects legitimate concerns that are typically omitted from expert risk assessments” ([75], p. 282).

In fact, risk judgements indicate more than just the perception of riskiness. They reveal global views on what matters to people, on technological progress, on the meaning of nature, and on the fair distribution of chances, benefits, and risks. Facing this dilemma, how can risk perception studies contribute to improving risk policies? Pertinent benefits of revealed perceptions may be as follows [20,25]:

- They can identify and explain public concerns associated with the risk source.
- They can elucidate the context of the risk-taking situation.
- They can enhance understanding of controversies about risk evaluation.
- They can identify cultural meanings and associations linked with special risk arenas.
- Based on this knowledge, they can be useful when articulating objectives of risk policies that go beyond risk minimisation, such as fairness, procedural equity, and institutional trust.
- They can indicate how to design procedures or policies that incorporate these cultural values into the decision-making process.
- They can be useful in the design of programmes for participation and joint decision-making.
- They can provide criteria for evaluating risk management performance and organisational structures for monitoring and controlling risks.

Social science research on risk perception has many implications, therefore, for risk governance. Even if there are no recipes to be obtained from analytical studies about risk perception, studies on risk perception can provide some insights that might help policymakers improve their performance [76,77].

Firstly, risk perception studies demonstrate what matters to people. In a democratic society, the concerns of people should be the guiding principle for collective action. Context and supporting circumstances of risk events or activities constitute significant concerns. These perception patterns are not just subjective preferences cobbled together: they stem from cultural evolution, are tried and trusted concepts in everyday life, and, in many cases, control our actions. Their universal nature across all cultures allows a collective focus on risk and provides a basis for communication ([63], pp. 146–147). From a rational standpoint, it would appear useful to systematically identify the various dimensions of intuitive risk perception (concerns assessment) and to measure the extent to which these dimensions are met or violated by the best available scientific methods. Many psychometric variables that matter to people are open to scientific study and scrutiny. In principle, the extent to which different technical options distribute risk across various social groups, the degree to which institutional control options exist, and the level of risk that can be accepted by way of voluntary agreement can all be measured using appropriate research tools. Risk perception studies help to diagnose these concerns. Scientific investigations can determine whether these dimensions are met or violated, and to what degree. This integration of risk expertise and public concerns is based on the view that the dimensions (concerns) of intuitive risk perception are legitimate elements of rational policy, but assessment of the various risk sources must follow robust scientific procedures on every dimension.

Secondly, designing policies about advancing, supporting, and regulating risks requires trade-offs between different concerns, as discussed in Sections 2.1–2.3. Such trade-offs depend upon both context and the choice of dimension. Perception research offers important pointers concerning the selection of dimensions for focus [62]. For example, the aspect of fairness that rates highly among people as an evaluation tool for the acceptability of risks plays a significant role in such trade-offs and in weighting the various dimensions. In their roles as risk assessors, experts have no authority to select these dimensions or

to specify their relative importance. This is where formal methods reach their limits as stated above. The multidimensionality of the intuitive risk model prevents risk policy from focusing one-sidedly on the minimisation of expected impacts or related metrics.

In essence, policy makers should be aware of public perception and concerns and take them as a legitimate input into risk management and regulation. Yet, concerns may be associated with problematic or even wrong (poor) causal models or they may simplify these models to such a degree that they are not useful for effective risk management and regulation. Thus, public input is important for (i) identifying concerns but not necessarily for measuring their potential impacts and (ii) for providing value judgement with respect to unavoidable trade-offs in the case of conflicting values or objectives.

2.5. Three major strategies are needed for managing or governing risk: risk-informed, cautionary/precautionary and discursive strategies

Being risk-informed means both: using risk assessment to understand and characterise risk, reflecting potential impacts – their sources and their effects, likelihood and related knowledge aspects (such as judgements of the strength of knowledge supporting the likelihood assessments) – and being aware of and attentive to public perceptions and concerns. The risk and concern assessments inform the decision makers, as highlighted many times already. The assessments are methodologically justified judgements made by the risk analysts and related experts in the field of study. The risk characterisations, which traditionally have been in the form of some type of probability statements, are conditional on the analysts' and experts' knowledge. In this sense the risk characterisations can be viewed as conditional on experts' methods, data reliability, modelling assumptions, etc. The decision makers would prefer unconditional assessments that can be taken as 'true, objective' values that they can use for costs-risks-benefit balancing. Instead, they are faced with a variety of assessments, sometimes contradicting each other. Furthermore, as explained above, these assessments may not cover all the concerns that people associate with the risk source and do not address the resolution of conflicting values and the trade-offs that are required. The results of risk assessments may all be informative in the sense that they give insights about some aspects of the risks, but there are still open issues, as the knowledge on which these assessments are built could cover or conceal risks. Thus, for the decision makers, there is a need to see beyond the risk assessment, to properly take into account risks and uncertainties, as well as attributes and values not considered in the risk assessment [6,22].

For many risk issues, the risk assessment results are not controversial, and the knowledge is sufficiently strong to produce a functional relationship between probability and amount of damage that is empirically proven and theoretically sound. In this case, a risk-informed strategy on the basis of formal risk assessment provides a clear rationale for risk reduction and also for risk communication [9]. Many routine risk situations fall into this category, such as wearing helmets when riding a bicycle, limiting the concentration of chemicals well below the threshold of toxicity, requiring passengers to wear seatbelts, setting building codes for the stability of constructions and fire prevention, or banning fluids from being brought onto an airplane. Most of these routine risk-based decisions are not controversial. They cover a wide range of daily activities, and scientific risk assessments have made a major contribution to the reduction of these conventional risk problems over recent decades [66].

If we go beyond conventional, routine risk situations, the picture becomes more blurred. As previously discussed, many particularly complex risk situations require a broad set of multiple characteristics with trade-offs between them. Assigning trade-offs, in turn, depends on the underlying value priorities of those who perform the judgement. In a democratic society, these judgements need to be part of a due process legitimised by democratic institutions.

In addition, there are often considerable uncertainties related to the

consequences of each decision option. For both reasons, uncertainty and value ambiguity, a risk-informed approach is not sufficient and needs to be augmented with other principles, mainly the cautionary strategy (broadening the precautionary principle) in the case of high uncertainty and the discursive strategy in cases of high ambiguity [9,46].

Let us start with the case of high (or deep) uncertainty. We can choose swine flu as an example: here we face major scientific uncertainties about the consequences of the swine flu. No reliable prediction model was available at the time. Risk assessment could have been performed but, because of the uncertainties, the assessments provided only poor knowledge about the consequences and the fraction of people that would be affected. Yet, the authorities needed to act to avoid serious damage. In most European nations, the authorities applied the precautionary principle, which invokes that, in the face of scientific uncertainties about the consequences of an activity, protective measures should be taken to reduce risks.

At first glance, it may seem intuitively plausible to act according to the principle: better safe than sorry. Yet, if doing nothing is also seen as a decision option, the principle may lead to dilemmas. This can be illustrated again with the swine flu example. What does the precautionary principle mean from the perspective of each individual who is confronted with the choice of getting vaccinated or not? Each person will be exposed to the side effects of the vaccination, again associated with uncertainties and ambiguities. The decision not to undertake vaccination can be interpreted as an application of the precautionary principle on the individual level. Many people did in fact select this option and avoided vaccination. From a scientific perspective, the odds of suffering from negative side effects caused by the vaccine were judged as significantly lower than the odds of contracting the disease. However, both judgements were associated with a high level of uncertainty so that unanimous proof in the form of a clear-cut risk assessment was not available.

We are therefore left with a dilemma: the general rule of precaution can lead to different conclusions depending on the choice of the default option and whose perspective we take [64]. If we regard vaccination as the default option, we should make sure that almost everyone is vaccinated in order to be on the safe side when there is a danger that the flu might spread throughout a population. If, however, non-vaccination is the default option, we would opt for abstaining from any vaccination campaign since there may be negative side-effects associated with the vaccination. Both judgements can be justified in reference to the precautionary principle. The example demonstrates that the application of the precautionary principle cannot be seen isolated from judgments of risk, uncertainties and other concerns. From an individual perspective, the non-vaccination may be seen as the natural default option, and then the application of the precautionary principle needs to be balanced against the risk related to contracting the disease. From the societal point of view, the natural option is the opposite, and the application of the precautionary principle has to be balanced against the risk of getting serious side-effects.

Many risk theorists have addressed this problem and there are many suggestions for how to interpret the principle and deal with this dilemma [16,45,80]. In practice, the precautionary principle has been invoked when a new chemical or a new activity has been proposed and, given large uncertainties, the pure plausibility of such impacts was enough to justify regulatory actions. It seems wise to protect society from risks characterised by a weak knowledge basis, but it needs to be used with care.

The cautionary principle extends the precautionary principle [9]. It states that if the consequences of an activity could be serious and subject to uncertainties, then cautionary measures should be taken or the activity should not be carried out. Whereas the precautionary principle is invoked in case of scientific uncertainties, the cautionary principle is used for all types of uncertainties and ambiguities. The point is that if the activity considered is associated with the possibility

of major negative consequences, regulatory measures are justified to avoid these consequences (or to limit them), even if they are not yet sufficiently known to science or accurately quantified using any formalised method. Furthermore, situations with large uncertainties may demand more control and monitoring activities, including limitations of their use in time and space, than more certain situations with a higher calculated risk of a negative side effect occurring [46]. The risk assessments alone may not justify any measures, yet weight given to the cautionary principle or strategy may do. Many emergency preparedness measures are hard to justify on the grounds of risk calculations, but they are implemented because of a cautious strategy. By the same token, many countries avoid nuclear plants. The potential consequences of accidents are extreme, and history has shown that dangerous situations may occur, despite the low risk numbers produced by the risk analysts.

The cautionary strategy is supported in robustness and resilience-based thinking and management (governance). To improve the robustness and resilience we do not need to calculate probabilities and risk metrics. We know for example that resilience can be improved by strengthening immune systems, diversification and flexible response options [63]. In recent years there has been an increasing acknowledgement of the need for this type of thinking and management, to meet uncertainties and potential surprises. We see today many people and organisations even make a call for a shift from risk to resilience. However, as discussed in for example Renn [63] and Aven [7], there is no conflict. Resilience management and governance is a key strategy of modern risk management and governance. It does not replace risk management and governance, as we also need to address risk to understand how and when serious threats may occur, and avoid them, and also guide the resilience management to use the available resources in a best possible way. For further discussions about the link between risk and resilience, see Linkov et al [51] and Aven [7].

The above dilemma identified for the precautionary principle will also occur in relation to the cautionary principle. In risk management and governance there will always be a need for balancing different principles and concerns. Yet such principles can provide useful guidance as they point to how to think, what aspects to consider and give weight to.

The third strategy is closely related to the experience of value differences in society. As risk judgements are multi-dimensional constructs, it is hard to imagine that any decision option will be dominant on all dimensions and meet all the values of the affected populations. Most collective decisions today face conflicting values and objectives. This is also true for risks. In addition, many individuals and groups may question the justification of or need for the foreseen benefits. Examples here are pesticides or therapeutic cloning. In cases of strong value conflicts and normative ambiguities, a third approach to risk management and regulation is required: the so-called discursive strategy [68]. This strategy is essential to reach a societal consensus on the type of values and choice of objectives that the respective society will or should pursue when making collectively binding decisions, or on what priority should be given to what kind of values when trade-offs are being made.

Discursive methods of risk governance are not a one-way transmission of information from the authorities to the public, expressing the 'facts about risk', as was previously common, for example when authorities were arguing that an industry is safe because of some low calculated probabilities. Rather, the point of departure is the acknowledgement that risk cannot be captured by a single dimension (for example expected cases of cancer per year) but requires a reflection about the potential benefits and risks (costs) from a broad plural value perspective including public concerns and risk perception. Dialogue and public involvement processes revealing the different positions and perspectives can, in many cases, lead to an improved understanding among relevant stakeholders, increase awareness of and sensitivity to the dilemmas and concerns that are at stake, and explore common ground for making the necessary trade-offs. If these processes are well designed and conducted, they may lead to a common understanding of

the problem and widespread support for a risk management solution. A successful example is the three-party dialogue introduced in the Norwegian oil and gas industry, where a formal collaboration is established between the authorities, the industry and the unions [13,50,70].

In summary: for most of the routine cases of decision-making, formal methods such as risk analyses and cost-benefit analyses are adequate. They are effective in terms of public protection and efficient with respect to wise use of resources. However, tests should be performed to ascertain whether risk management decisions and/or regulations violate fairness principles or other forms of values, and whether the decision situation is associated with more uncertainty than appears at first glance. If the risk situation is characterised by high uncertainties, we recommend the application of the cautionary strategy, which implies a proportional balance of benefits and risks (costs) and allows risk managers and regulators to place an extra weight on high levels of uncertainties and weak knowledge bases, that may justify extra efforts of risk reduction and prevention. These extra efforts rarely include bans or prohibitions but, rather, limitations in distribution (space and time) in order to avoid irreversible decisions and strict monitoring and containment requirements. Finally, if risks invoke many conflicting values or concerns, a discursive strategy is required that provides a process of deliberations and stakeholder involvement, aiming at a societal consensus of compromise when assigning trade-offs.

2.6. Government should be open and transparent about its understanding of the nature of risks to the public and about the process it is following to handle them

History has shown that governments are not always open and transparent about their understanding of the nature of risks to the public and about the process they follow in handling them. Two illustrating examples are the so-called 'mad cow disease' (Creutzfeldt-Jakob disease) in the UK in the late 1990s [60] and the nuclear risk in the 1970s and 80s [35]. The perspective taken was that the risks were well managed by private companies and public regulatory authorities and were essentially negligible. The uncertainties were not properly acknowledged or communicated. Such a 'we know best' strategy has led straight to the lack of trust in the authorities that many agencies and risk management institutions face today. Most people assume that the authorities try to balance different concerns and interests and like to avoid 'unnecessary' stress and panic. That is one reason for their suspicion if the authorities pursue a typically paternalistic style of risk management and regulation. The authorities will lose public trust and lack credibility when they justify their decisions. We also observed this effect in relation to the swine flu vaccine [71]. Public authorities said little about the potential negative side effects of vaccination in order not to worry the public. It was exactly this attitude, however, that created public outrage in many countries.

The authorities are of course faced with a dilemma. Although openness and transparency are in general desirable, their uncritical use can have severe negative effects, such as stress and panic in huge populations. Yet empirical research has demonstrated that open information about potential threats has very rarely resulted in panic or over-cautious behaviour [34,61]. On the contrary, when information is withheld and then suddenly released by third parties, panic reactions are more likely to occur. Given the overwhelming evidence in this issue, we strongly recommend that openness and transparency should be endorsed and practised. It helps people to be aware of the risks that they face and, in the long run, to build trust in the authorities.

People today seek the best information available. Public authorities should take a leading role, not camouflage their knowledge. The challenge is to develop a professional language and terminology that makes this communication work effectively. Current practice is not sufficiently developed to characterise and communicate risk and uncertainties in a

way that different target audiences can make sense of and act accordingly. Public authorities need to invest extra effort not only to make information available to a general public (by placing it on a more or less hidden web account) but also to initiate communication programmes for each of the relevant stakeholders and target audiences. A huge challenge for authorities is to make scientific and professional reports comprehensible for the public. The transformation process may easily lead to biases at least for one party in the debate. It is not sufficient to refer to probabilities – they also need to say something about the knowledge base on which these are founded. If we think again about the swine flu example, a balanced way of expressing the risk would be to say:

The vaccine could have unknown side effects. Some of them are known and we can control them, others are not and we do what we can to investigate and monitor them. We think it is unlikely that severe side effects will occur, but the knowledge base is rather weak and we cannot exclude the possibility [5].

What is balanced can of course be discussed. One of the reviewers of the present paper commented that the parents of a child which developed narcolepsy as a consequence of the vaccination would probably not call this expression of risk balanced – they are now suing the government for damages. As a response we would comment that the authorities did not present risk in this way. Rather the typical format was ignoring the risks related to potential side-effects as mentioned in Section 1. Using a risk expression as above, the many relevant aspects of risk has been revealed, in a way which we find rather balanced.

We know that many people have problems in understanding and acknowledging uncertainties: as long as there is a possibility, the event is bound to happen. We need better methods and processes that help people to gain a balanced perspective on risks, uncertainties and probabilities. Examples are needed from real life, showing that we live perfectly well with risks and uncertainties – for example in relation to traffic. We need to be crystal clear what a probability means, for example, when stating that the event will occur with a specific probability. The current nomenclature, as used in practice, is not good enough for effective communication. We rarely hear authority officials providing clear interpretations of probabilities. How can we then obtain successful communication with the public? (See Aven and Renn [11] for some specific guidelines in relation to these issues.)

The main lesson for risk managers and regulators is that transparency and openness are essential for gaining trust and confidence. Sometimes such openness is not well understood, and information may be taken by a special interest group to serve their specific interests and to mobilise public outrage. Withholding information, however, is not an adequate solution for avoiding this. On the contrary, if this strategy becomes known to the public, one can expect an explosion of outrage and accusations. Rather than trying to filter information, public authorities should concentrate on methods of how to best communicate risk information and how to engage stakeholders and the public in constructive risk management dialogues. Many risk communication guidebooks and public involvement manuals have been published that provide valuable guidance to the authorities. There seems, however, a reluctance to pursue this path and to follow this advice. With the exception of proprietary information and information that may damage public security (for example strategies against terrorism), an open and transparent information policy is recommended.

2.7. Governments should seek to allocate responsibility for managing risks to those best placed to control them

This principle is based on the conviction that the risk management of any activity is best carried out by those who can control the activity. It reflects the basic idea that “one cannot be held responsible if one is not in control”. Risk related to driving a car is best dealt by the driver, whereas the swine flu risk needed national and even international

handling, as the threat is intrinsically borderless. A fundamental principle often applied in industry is internal control, meaning that the company has full responsibility for the activities it runs, including the risks [19]. This principle has two aspects. Firstly, it requires that inspection, monitoring and control are performed at the lowest possible governance level, while the rulemaking should be arranged at the highest possible level to ensure fair treatment of all constituencies and equal access to markets and innovations. The rules should apply to all (within limits), but implementation and control should be carried out at the local or regional level. Secondly, the rules should state the goals and objectives of the regulation; the various means of how to meet these goals should be left to the institutions that are obliged to manage the risks. For example, regulation may require that a company reaches a specific target emission; how this emission is accomplished, by changing production processes, installing more filters or substituting material, is for the company to decide.

As for all such principles, both targets must be implemented with flexibility. The risk management related to driving a car cannot be left to the driver alone. Society has introduced many measures and constraints to ensure that drivers can rely on safety features in their cars and on the assurance that other drivers are also qualified to drive a car. Drivers are hence obliged to obtain a driving license, the car needs to meet specific technical quality requirements, speed limits are enforced, etc. Similarly, the internal control has many limitations, as society is not willing to allow companies to be totally flexible in how they meet standards and limitations. The choice of means may have other negative side effects, which makes it necessary to limit or regulate them, too. If pollution standards are met by using scrubbers and filters, which then need to be discarded in landfills, alternative options such as changing the production process to avoid pollutants in the first place may be required by state law. Furthermore, society rightfully involves agencies to check that the companies have implemented suitable systems that enable them to manage the risk properly.

In essence, governments should strive to allocate responsibility to those that can control the risks. There will always be limitations to this general principle, but those need to be justified. We consider it essential that as much as possible of the risk management is conducted by those that can best control the risks. Only then we can obtain the energy, innovation and creativity needed to maintain and improve the relevant activities and systems to avoid disasters. If the authorities are too specific about the means of risk management, it is obvious that efficiency will be sacrificed and often also the effectiveness in risk reduction.

2.8. Intervention is needed in the case of market failure or equity issues

There is much evidence showing that the use of seat belts is very effective in saving lives and reducing injuries in automobiles. For many years, however, many car occupants did not use the belts, and the situation was considered a market failure [3]. From a societal point of view, risk reduction could be substantially improved if a seat belt law were rigorously enforced. Governmental intervention was seen as legitimate, despite conflicting values like personal freedom. Smoking is another similar example.

There are many examples where equity issues have been neglected, in relation to both time (e.g. future generations) and social groups (e.g. exporting hazards to developing countries) [41]. The way risk is commonly characterised, using losses and probabilities, and also the use of cost-benefit analyses, normally does not highlight such issues of distribution. Ethical considerations may, however, require regulatory action, even if the activity in total is cost-effective, as discussed in Section 2.1. For example, concentrating hazardous facilities in poor countries may be seen as a violation of equity, even if this provides revenues to these countries. Using national resources to build hospitals for the political elite, while the rest of the population is left with poor health care, is another example where equity considerations require

regulatory interventions.

These are just some examples showing that interventions are justified in cases where desirable societal goals are not met, from either an economic or an ethical point of view. In practice, the issues are less obvious than in these two examples, but the two examples clearly show the need for correction. For further discussions of the ethical aspects related to risk and risk analysis, we refer to Hansson [33] and Ersdal and Aven [23].

3. Discussion

The concern has been raised that our societies have become too risk-averse and that this development has a destructive impact on public policy and governmental risk management; see for example UK [84]. As suggested by the UK Prime Minister in a speech in May 2005, “We are in danger of having a disproportionate attitude to the risks we should expect to run as a normal part of life” and this is putting pressure on policy-makers “to act to eliminate risk in a way that is out of all proportion to the potential damage” [84].

It is not difficult to find examples where this type of concern is justified. The UK [84] report mentions some examples, including defensive attitudes in the practice of medicine. Another example is the public management systems, commonly used today, which highlight bureaucratic requirements and reporting at all levels of the organisations. Over-regulation easily leads to a culture where the main focus is compliance to these requirements and criteria and not the overall performance of the organisations and their main functions, including the management of risk. The result is easily a lack of innovation and an impediment to changes that are required to advance the organisation to meet the needs of the future.

However, at an overall level, we have concluded that governments in general manage and govern risk in a balanced way and that these concerns about too risk-averse policies are rarely justified. Let us use the case of passive smoking as an example. In recent years, we have seen a trend for governments to ban smoking in public places, often following intense discussion. The arguments for the ban relate to health and wellness. In UK [84] the evidence for such a ban is questioned. It is indicated that the decision to ban smoking in public places may represent a disproportionate response to a relatively minor health concern. This reasoning demonstrates the subjectivity of the framing of the problem raised by the bureaucrats that have produced this report. Their perspective is rather narrow and fails to incorporate several issues of importance for making the decision, for example the strong belief of people that they should not involuntarily be exposed to a risk source that is easy to avoid. Passive smoking is not only about lung cancer risks but also about the right of a person to use public places without being subjected to the health-damaging activities of others. Politicians need to take a comprehensive approach and reflect on all aspects, also changes in attitudes to smoking and passive smoking when such a ban is implemented. Experience from other countries has shown that people are pleased with the change, even if there was a lot of protesting at the time of implementation. It is tempting to believe that many developments in society would not have been realised, if analysis alone had determined what ought to be the basis for making collective decisions, particularly when based on a one-dimensional risk assessment or traditional cost-benefit analysis. At the same time, risk assessment has been extremely helpful in reducing risks and making life in modern societies healthier and more comfortable over the years. As always, it is the delicate balance between regulation and freedom that makes the difference between investments into innovations and changes on one hand and preservation of the present condition on the other hand.

If we look at the eight principles here recommended, most of these are at least partially implemented. We will point to seven areas where the potential for improvements is highest, when aiming for excellence in governmental risk handling:

- a) The way to inform about risk. Informing people using probabilistic analysis is not sufficient. Broader characterisations are required; also, judgements of the strength of the knowledge supporting the probabilities are required, as well as considerations of potential surprises relative to the available knowledge.
- b) The understanding that evidence is related not only to facts but also to beliefs and concerns that need to be incorporated into risk management and regulation, without going overboard by replacing assessments with public perception surveys.
- c) The understanding that value judgements are equally important as a basis for decision-making as evidence in the form of data, information and justified beliefs.
- d) The understanding that cost-benefit type of analysis can support but not determine decision-making. Balancing risks (costs) and benefits is crucial for making wise decisions, yet the net balance is often insufficient to address other values than risk reduction, particularly impacts on equity and distribution.
- e) The understanding that, whatever tool is used to capture risks, it cannot provide a comprehensive answer regarding what is the best decision in relation to risk.
- f) The understanding that risk-informed, cautionary and discursive strategies need to be employed, depending on the degree of uncertainty and ambiguity of the issue in question.
- g) The understanding that the common rules for risk management and regulation should be made at the highest political governance level possible, but implementation and control should be organised at the lowest level reasonable.

To meet these challenges, risk assessment and management institutions, as well as regulatory agencies, should take more responsibility for dealing with risk in a multi-objective, multi-value and multi-actor environment. Academic research and management expertise are both crucial for informing agencies and institutions on how to improve their performance and to strive for a better balance between necessary changes and cautionary approaches to protect what has been accomplished in the past.

Concerning the need for proper risk concepts and characterisations supporting the risk analysis as pointed to in item a), different frames can be used. One of the most general ones is presented by the SRA [79] glossary, see also summary in Aven [6]. Alternatives exist as in Connelly and Lambert [17] and Thorisson et al [83]. By suitable reformulations, many of these alternatives can be considered special cases of the SRA glossary set-up which views the risk concept to have two main features: i) events/scenarios and related effects with respect to something that humans value, and ii) uncertainties. For example when Thorisson et al [83] refer to risk as the influence of scenarios on priorities, it can be seen as a special case of i) where priorities is the effect of interest, and with the uncertainties ii) tacitly included.

4. Conclusions

Inspired by insights provided by the risk analysis field in recent years, we have presented and discussed eight principles that governments should apply in order to properly deal with risk in society. We believe that these eight principles can improve current policies and be useful for both bureaucrats and politicians, in their work on developing and implementing policies on risk management. Our analysis is also intended to address risk researchers. In relation to current practices, there is a potential for improvement that needs academic investigations and comprehensive expertise. These relate to both the understanding of the fundamentals of risk assessment, management and governance, and practical instruments to be used to conduct risk analyses and support decision-making. A main conclusion is that governments in general deal with risk in a fairly balanced way, but that they need to improve their understanding of the interface between facts and values in risk management. The use of cost-benefit analysis and concepts like ‘evidence

based decision making' are not obsolete, but they need to be enhanced with more risk- and dialogue-oriented policy styles.

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