2

Reflections on Risks and Technology

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2.1 Risks and Technology

Human activities are connected with risks. Throughout our history, managing and controlling these risks has built on the experience of generations. Industrialization meant a partly new situation. People began to work increasingly in groups, in mines and in factories. New technology was introduced, although slowly at first and in small establishments. Experience was lacking, and the technology was often difficult to understand. An accident could hit many people at the same time. In order to handle the risks, one tried to combine the few available data on accidents with engineering calculations – the start of what would become modern risk analysis.

The nineteenth century saw the advent of railways. Pressure vessels were used in steam engines and in turbines to produce energy. The large number of accidents connected with this development resulted in an increased public control (Chapter 3). The same development could be seen in other areas. In the beginning there was a patchy technology and, after some accidents – regulations and control. A characteristic feature at that time was that the management of risks came mainly as a reaction, after an accident had already happened.

Today the situation is in many respects different. Achievements such as new aircraft, roll-on-roll-off ships, nuclear reactors, pesticides, and so on represent large systems that were rapidly introduced. The number of units in such systems can be small and the economic lifetime short. Therefore, one cannot expect to gain a thorough experience of all their safety aspects. Instead one must, to an increasing degree, analyze the risks with the help of mathematical models and through a study of the interplay between man, technology, and organization (see, e.g., Chapters 13 and 15).

Media play an increasing role in modern society. News about catastrophes and accidents is rapidly spread over the globe. People find it interesting to read about accidents, and therefore risk problems are brought to public attention.

A substantial advantage of a new technology is often not sufficient for the public. They demand that one can handle, and preferably eliminate, the risks. It can

be difficult to explain how the benefits can be weighed against a single possible catastrophe.

2.2 What is a Risk?

What meaning does the concept of "risk" have for individuals, for groups of people, and for the society? What research is carried out on risks? Risk is a word with many meanings. Its origin is unclear, but it probably came from classical Greek and referred to accidents at sea. Through Latin it has since been used in many modern languages. In colloquial language, a risk means a harmful event that may occur, but not with certainty. It can refer both to probability and consequences.

In research, the word risk is given a more precise meaning to describe certain concepts. One common way to use the word is to let it refer to the probability of the occurrence of a harmful event. If there is a measure of how harmful the event is (for instance the number of fatalities in a sea accident), the risk may sometimes mean the product of the probability and the amount of harm. Statisticians call this an expected value, and it has often been used to specify the concept of risk. A third use of the word has to do with the variation in the result, if a certain measure is taken. An example could be the variation in travel time going by train or car, i.e., the risk of delay. A fourth definition is the experienced risk. That is, how large an individual considers the risk to be, with the individual's own interpretation of the word risk (Slovic, 2000; Renn, 2004). Of course, the meaning one gives to a word is to some extent arbitrary. There is no "true" definition of risk. Even so, the concept of risk can be seen as a combination of a random event with negative consequences for human life, health, or environment, and the probability of that event occurring. We exclude, for instance, economic risks, even though they are often part of the basis of a decision.

Risks are usually connected with some kind of decision, for instance whether one should allow or ban the use of a certain pesticide. Often there is a choice between various safety precautions, and their cost is then a part of the problem at hand. One may identify three groups that are affected by a decision, which involves risks: the risk carriers (i.e., those who may be affected by the negative consequences), the benefit (cost) takers (i.e., those who benefit from the decision and pay for the action) and finally the decision-makers. It is characteristic of new technological systems that these three groups are not the same. That makes an analysis of risks even more important. Such an analysis contains three elements: What can occur, how likely is its occurrence, and how do we value the consequences?

Risk analysis has a long history in several technological areas, for instance in solid mechanics. A more recent aspect is the need to approach problems about risk from several different points of view. The different chapters in this book give many examples of such interdisciplinary approaches.

2.3 History of Risk Research

Research on risks took big steps forward around 1970. The background was the growing opposition to nuclear power, and concerns about the environment. Suddenly, there was a strong and increasing opinion that created a serious obstacle to certain kinds of technical development and industrial expansion. Technology and industry were no longer considered to be unambiguously good, and the concept of "quality of life" got also a dark side. Media and the public opinion together demanded a new policy that took into consideration the environment and human health – and also recognized their own anxiety, even though such anxiety was sometimes regarded as unjustified by experts.

A first approach was to estimate the magnitude of various risks, in everyday life as well as that of large but rare catastrophes in technical systems and in the environment. Smoking was already then a well-known and thoroughly researched risk; in fact one of the largest risks in the everyday life of smokers and their surroundings. One could compare the risk of smoking with that of living close to a nuclear power plant. The smoker was subject to a much larger risk, if one believed the available risk analyses. But this did not calm those who were against nuclear power, even if they were smokers. Researchers realized that it was necessary to try to understand the factors that affect how people react to risks.

The leading person in the initiation of risk research is Chauncey Starr (1969). He showed that the actual risk gives a very incomplete explanation of how society handles risks. In order to understand social reactions to risks other concepts had to be introduced. Starr suggested voluntariness. We seem to be prepared to accept much larger risks if they are voluntary than if they are forced upon us. This was a fruitful idea, and the origin of much of the subsequent research on risk perception. However, it was only a start. Why is leisure sailing more dangerous than traveling on a car ferry? The latter is not really "involuntary." Many examples can be given where voluntariness seems to be an unlikely explanation of risk acceptance. Other dimensions were suggested, leading to the psychometric model of risk perception (Fischhoff et al., 1978) where dread and novelty of risk emerged as important factors.

Risk appears to be very important in policy discussions. Why is it so? It is not obvious that risk is an important aspect of our actions. We can choose between avoiding risks or taking the chance to get what we strive for. It is not unusual that the most risky alternatives are also those that may give the largest benefit. To bet money on a horse that few believe is a winner means a large risk. It is probable that we shall lose what we have bet. But if, on the other hand, the horse comes in as the winner, we can collect a nice profit. Risk thus has two faces, and we may take risks to achieve what we want; power, money, joy, excitement, etc.

Nevertheless, the public image of risk is mainly negative. The mountaineer takes a risk and he does so voluntarily – he seeks the risk. But does he really believe that there is a significant risk of dying? Hardly so. He believes that, through his skill, the danger can be kept under control. Perhaps he yearns for exactly that feeling of control, and to show courage and skill. One theory, called the theory of risk homeostasis, says that people want a certain level of risk, and therefore adjusts their actions to reach that level. If you use winter tires, the safety

on a snowy road increases, but most car drivers who use winter tires drive faster and thereby restore the risk level to some extent, even if they do not do so fully. Is that because they want to drive at a certain risk? The example shows merely a willingness to accept a certain risk level. What the driver really wants is to save time.

2.4 What Is an Acceptable Risk?

We have seen that risk research first started from the notion that people found that certain risks were "too large," and researchers tried to explain this attitude. Later, researchers became interested in what can be called risk denial. For instance, it turns out that most people think that they are exposed to much lower risks than other people. This could be true for many, but not for all. Furthermore, almost all investigations of risk perception show that many people find almost all risks to be utterly small: 3–4 times as many as those who find risks to be alarmingly large. But not all risks are non-existent or extremely small. Society must be prepared to anticipate and reduce risks before serious accidents happen.

Who is to decide whether a certain risk is to be accepted or not? Legislation and regulations can prevent people from taking risks that could hurt themselves, and from exposing other people to risks. The latter aspect is not uncontroversial, but is it reasonable to prevent people from taking risks that would hurt only themselves? Consider, for example, the use of seatbelts in cars. It was relatively rare until it was made mandatory through legislation. Of course, such a law was introduced for the benefit of people, and it involves only a minor limitation of the individual's freedom. Furthermore, society had a strong interest in reducing the high costs for hospital care and other medical consequences – particularly when most of those costs are borne by a social welfare system. But still – is it reasonable that society decides which risks an individual may take?

There is much to be said about ethics and risks. A certain activity can be beneficial for society, but perhaps not equally so for each individual (Figure 2.1). A nuclear power plant is not of much direct use in a sparsely populated part of the country, where hydroelectric power is abundant. Who should bear the risk associated with the nuclear waste? Where should the waste be deposited? Should it be in the densely populated region where the nuclear plants are located, and where most of those live who benefit from the nuclear power? Or should it be deposited in remote areas where few people live, in spite of the fact that the people in this region could meet their energy needs with a small hydroelectric plant?

In the theory of economics, it is assumed that people try to maximize their expected benefit, and that this means that a decision is based on the simultaneous consideration of the possible cost (damage) and the benefit. But risk research has shown that the possible damage is in most cases much more important. The benefit often plays a less prominent role. This is something familiar to decision-makers. In almost all countries it has been difficult to find a site where the local inhabitants are willing to accept a nuclear waste deposit, regardless of assurances that the technical problems have been solved and that there is no risk, now or after thousands of years, to those living nearby. People have not been willing to accept

economic benefits in return for what they consider to be health hazards to themselves, their children and their grandchildren. The dominant factor by far is the risk aspect.

Figure 2.1. A crane lifts a nearly 200-ton nuclear reactor safety vessel at the Indira Gandhi Centre for Atomic Research at Kalpakkam, India, June 24, 2008. The reactor is a 500 MW prototype fast breeder and it is planned to begin commercial production by 2011. (Photo: Babu/Reuters/Scanpix)

A common idea, often ascribed to the American psychologist Maslow (Maslow, 1970), is that people's needs can be arranged in a hierarchy. At the lowest level are certain primary needs of food and drink, etc., which must be satisfied before one engages in higher levels of needs. Thus, for example, poor people would not be expected to be as concerned with long-term environmental risks. But research has shown that Maslow was mistaken. Even people living under very difficult conditions retain their ability to engage also in that which lies beyond

the toils and threats of their daily lives. This is very important for politicians and businessmen. Many of them have thought that exporting the waste to developing countries could solve part of the environmental problems of the rich world, such as hazardous waste.

But is risk something that really "exists"? Of course, an accident or a disease can hit people, no one denies that, but that is not the same as saying that risks exist (Breakwell, 2007). A risk is an expectation that something negative may happen. Thus it is a subjective phenomenon. Of course, this does not mean that the actual thing, which is expected, is also a subjective phenomenon. On the contrary, accidents and damage are very real. And our expectations contain some valid knowledge, otherwise we would not survive. Having said that, we now must step back and take a new look. Anticipations and worldviews are culturally dependent. In that sense, risk is a culturally dependent phenomenon, and not entirely a function of reality. Many other aspects come into play, but nevertheless – people's anticipations usually have a basis in something real. It would be completely wrong to draw the conclusion that risk perception is entirely a question of subjectivity and culture and that it lacks connection to reality. This question is further considered in Chapter 16.

2.5 Society's Reaction to Risks

In industrially developed countries, people are often concerned with risks associated with technological progress. An increasing part of the issues discussed in political circles deals with risks. It is interesting to ask why this is so. One explanation is that society cannot launch new and expensive welfare reforms to the extent that was previously possible. The politicians therefore turn their attention elsewhere. Another explanation is that we know much more about risks, or that risk levels have actually increased. It is true that we know more, but the risks themselves have hardly increased, as is corroborated by a higher standard of living and a significant improvement in the public health.

The introduction of new technology often leads to fierce debates. Research shows, however, that it is hardly the "novelty" per se that is negative. On the contrary, "novelty" is in many cases a positive argument. Instead, the reaction seems to depend on whether or not the new technology is conceived as being necessary, or perhaps even irreplaceable (Sjöberg, 2002). The Internet is a new technology, as is e-mail, but people do not seem eager to abolish it. On the contrary, the attitude is very positive. Railways represented a new technology in the nineteenth century, and in spite of accidents, few advocated that the building of railways should be stopped. Why not? The reason was probably that the new technology had many positive aspects offering faster and cheaper, and even safer, travel. At that time it was an irreplaceable technology.

Why does it seem to be a characteristic of man to worry about risks and to react to them? We can only speculate about this question, but it seems reasonable to view risk avoidance as being evolutionarily important. Of course that holds particularly for a being that does not have big muscles and sharp teeth and claws, and is not particularly fit to run fast and for long time to escape an enemy. Such a

being must be prudent and anticipating and avoid the danger before it becomes a reality, i.e., to engage in matters of risk.

In modern society, we are constantly being confronted with media, and the media present a lot of information about risks. Some psychologists suggested that it is the intensity of the media coverage that creates the risk perception (Combs and Slovic, 1979). That is a common view, which strongly appeals to common sense, but it has been difficult to verify the hypothesis. Of course it is often media that inform us about the existence of a certain risk, for instance when it became clear in 1996 that the "mad cow" disease can be transferred to humans through food. Since then media have been quick to note anything that is related to this new disease. But is it the media per se that create the risk perception? There are other possible explanations, for instance the associations and ideas evoked by the concept of the "mad cow" disease. We have a system of concepts ready to help us understand new situations. One would not like to eat beef from a "mad cow." "Nuclear waste" sounds threatening, dirty, and dangerous through the word "nuclear" and its connection to nuclear weapons, and the generally unpleasant word "waste," adds to this feeling. It becomes even worse if it is called "nuclear garbage," as realized by opponents to nuclear energy.

There are risks of many different kinds. Technological risks are just one form, another being natural catastrophes. People react differently to nature and its risks. Technology that is perceived as disturbing the order of nature, and this holds particularly for nuclear power and gene technology, is considered to be particularly dangerous for this reason (Sjöberg, 2000). It is assumed that man is biologically adapted to a life in harmony with nature, in nature's pristine condition before man has changed it. For some, this is a religious belief. What is in fact then meant by "nature" is no simple question, see Chapter 16.

Perhaps people are sometimes fatalistic, and do not consider it possible to avoid nature's risks. Further, there is no human responsibility for these risks – or at least there is perceived to be none. "Accident" is a concept that partly implies the idea that there is nobody to be held responsible for what has happened. One can never be sure that accidents will not occur.

Of course, all this is a simplification. Nature creates risks. But they can often be forecasted and we can protect ourselves. There is an interplay between the forces of nature and the technological systems that could sometimes have been avoided. For example, strong winds combined with a deficient construction of ships may lead to catastrophes; compare with Chapter 9.

Until now, we have discussed only risks to which we are involuntarily subjected. Such risks are strongly disliked. One of the first debates about risks dealt with fluoridating drinking water in order to prevent caries. It was an involuntary risk that was forced upon people, or at least it was probably viewed as such by many (Martin, 1989). Yet another type of risk is completely voluntary, for instance when we smoke or drink alcohol. It is characteristic of these cases that the activity in itself is pleasant, and that the risk each time one smokes or drinks is perceived as extremely small or completely negligible. We also think, in these cases, that we are subject to a much smaller risk than other smokers or drinkers (Sjöberg, 1998).

There are risks in our everyday life that we almost never think about, and simply discard. What if our neighbor smokes in bed and the house we live in is set on fire one night? What do we actually know about the habits of our neighbors, and how could we protect us against such a risk? Or the next time we fly – can we be absolutely sure that "the captain is sober"? (Of course, we cannot ask.) It is simply unreasonable to worry about all the risks in daily life, and even if we did worry about them, we could usually not protect ourselves without large costs – and at the same time take other risks.

We would prefer to completely avoid any environmental or technological risks. We want an "absolutely safe" technology. In the 1970s a law was introduced in Sweden decreeing that there must be an absolutely safe method to take care of the nuclear waste from Sweden's nuclear power plants before they were allowed to operate. But taken literally, is impossible to live up to such a requirement. This holds for any technological system. Some risks always remain, even if we claim to have done everything possible to avoid them. Moreover, it is rare that we want to do everything possible to avoid the risks irrespective of how small they may be. Other risks can arise, replacing those that were eliminated. The cost of decreasing the risk level usually becomes larger, the smaller is the risk. We get to a point where we are not willing to pay for further risk reduction.

This may seem obvious, but political examples show that this is not always the case. As another example from Sweden, the authorities have adopted the official policy that no person shall die in traffic accidents – "zero tolerance" policy. If this goal is taken literally, one may ask what the costs would be and what changes are required in the society in order to achieve it. Of course one can view it as a goal to strive for, but it is unrealistic to think that it can ever be reached. Is it good policy to have goals that can never be achieved?

Taking risks also has another face. Although it may be irrational to require absolute safety, this does not necessarily mean that we should always accept very small risks. Very great damage is something we may want to avoid, "at all costs." Perhaps we prefer a solution that has a higher risk, but where the consequences are smaller and easier to handle. An insurance company does not normally accept to insure something that could force the company into bankruptcy if the worst were to come to the worst, even if the probability is extremely small. In this connection, it is important to realize that small probabilities can almost never be determined with a high degree of accuracy. They rest on assumptions that may turn out to be incorrect.

One may also question our tendency to wait to act against risks until something happens. Risk policy is largely reactive rather than proactive and the actions that follow from a catastrophe may turn out to be very expensive and demanding (Renn et al., 1992). The handling of risks in modern society is full of examples of this. The economic analysis is given low weight after a catastrophe, when public opinion demands, "it must never happen again." Industry has a strong interest in restoring the confidence of consumers and the public, perhaps at a high cost. But there are also good examples of how safety can be increased without overly high costs, as exemplified by the air transport sector.

2.6 Risks in the Public Debate

What is rational when one has to decide about a risk such as a core meltdown in a nuclear power reactor? Of course one factor of importance is the knowledge one has about the field. In some sense, specialists and experts can be said to arrive at the most rational judgment, based on known and proven theories and models. But even they do not have, and never will have, completely certain knowledge about the issue under consideration. It is always necessary to make assumptions, and the expert's judgment can sometimes be questioned.

Often, other experts have objections and a fierce debate may start in the media. The public must base its risk assessment on its impression of the experts' reliability and on other information they have about them. We judge all people, also experts, based on psychological and social dimensions, some of which can be rational and very reasonable while others may be merely prejudices. Common to all these dimensions is that they give incomplete information. A Nobel Laureate often appears to be more reliable than an "ordinary engineer," but the Nobel Laureate may have worked on problems quite different from the risk issue, while the engineer has spent many years of qualified practical work in the field. We should therefore be careful not to let status be the only decisive factor in our judgment of reliability. A person with a strong personal and emotional engagement, and who shows that in a debate, can appear to be partial. But it may also be that he or she, on impartial grounds, has arrived at a strong conviction in an issue that is very demanding, emotionally and in terms of value. Problems of risk are often of such a character, and we should not be too quick to dismiss such a person. Perhaps the others are just better at disguising their emotions.

In risk debates, it is fairly common that people are talking at cross-purposes (Sjöberg, 1980). One of the reasons is that the word "risk" in itself is so ambiguous. One person can think about the probability of damage and claim that it is small, while another person may think of the size of the injury or consequences and, if that is very large, he or she can keep arguing that the risk is too large, no matter how much the first person claims that the probability is small. This is a type of argument that rarely works, since probability is a difficult and theoretical concept that few understand very well. Moreover, it is difficult to get an intuitive idea of small probabilities. Statements about small probabilities are also built on models whose assumptions can be questioned.

It is not uncommon that the debate strays off the subject. The parties accuse each other of being ignorant or "bought," or at least suspect that this is the case. Risk communication has emerged as a field of study to find ways out of the dilemma. Sometimes it is about attempts from industry to achieve public "acceptance," sometimes with the help of PR consultants (Stauber and Rampton, 1995). The latter have experience of advertising and may know consumers as being fairly uninterested but who can be influenced by irrelevant tricks. But when it is an issue about risks involving the life and health of an individual and of his or her family, people are not uninterested or credulous or particularly easy to sway with easy tricks. At the same time it should not be denied that the area of risk communication is very difficult and that research still has a long way to go. In the

end it seems to be a question of democracy. People must be given real influence, either directly or through their representatives. Compare with Figure 2.2.

Figure 2.2. Environmentalists camp in the shadow of Drax power station, Britain's biggest coal-fired power station. (Photo: John Giles/PA-EMPICS/Scanpix)

A special case that clearly illustrates the need for democratic control arises in cases where risky structures are built close to borders between countries (Löfstedt, 1996). In some countries one may have confidence in experts and authorities, in contrast to the situation in other countries. There can be historical reasons behind these different attitudes. In the USA and in Russia, there is a history of badly managed risks, for example in relation to radioactive radiation. In Eastern and Central Europe, mass media were for a long time in the hands of the rulers of the state, and critical information about such events as environmental pollution as not made public (Sjöberg et al., 2000). As a result, environmental pollution went a long way before the public realized what was happening and demanded improvements. At the same time, public trust in authorities and experts was undermined. Data indicate that people in these countries nowadays perceive great risks, and that they don't trust their own authorities and experts. Trust is easier to lose than to acquire. When lost, it is a demanding task to restore it.

Social trust is important for understanding reactions to risk (Slovic et al., 1991; Frewer at al., 1996). Often it is assumed that risk debates can and should lead to the building up of public trust in experts and authorities. But some skepticism is always healthy, since experts can be wrong (Sjöberg, 2006). Furthermore, many members of the public are skeptical as to whether science really has such completely correct answers that risk analyses on a scientific basis can be considered to be completely trustworthy (Sjöberg, 2001). In fact, all researchers know that science does not hold the final answers about anything, science always

asks new questions. Uncertainty must therefore be debated. People want to know about it (Frewer et al., 2002). Risk is a theme that involves many psychological and social factors, in addition to the purely technical complex set of problems that has to do with measuring and controlling risks. The technical part is of course indispensable, but so is the human part. We cannot hope to be able to manage risks in a better way in society if we do not understand how people react to them.

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