

Risk Management: the Economics and Morality of Safety Revisited

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Abstract

The introduction to the proceedings of the Royal Academy of Engineering 2006 seminar on *The Economics and Morality of Safety* concluded with a list of issues that were “worthy of further exploration”. I have reduced them to the following questions:

- Why do moral arguments about ‘rights’ persist unresolved?
- Why can risk managers not agree on a common value for preventing a fatality?
- Why do governments and the media react differently to different causes of death?
- Why do some institutions profess to be pursuing zero risk, knowing that achieving it is impossible?
- Why do some institutions pretend that their risk management problems can be reduced to a calculation in which **all** significant variables can be represented by a common metric?
- Why are societal attitudes and risk communication still seen as problematic after many years investigation?
- Why are certain accident investigations, criminal or civil, seen as ‘over zealous’ by some and justifiable by others?

These questions are addressed with the help of a set of risk framing devices. For some my conclusion will be discouraging: all of these issues are likely to remain unresolved. Risk is a word that refers to the future. It has no objective existence. The future exists only in the imagination, and a societal consensus about what the future holds does not exist.

1 Background

In April 2006 the Royal Academy of Engineering published the proceedings of a seminar on *The Economics and Morality of Safety* (RAEng 2006, henceforth referred to as TEAMOS). The proceedings were published with an introduction by John Turnbull. Unusually for such an introduction he focused not on the achievements of the conference, but on the problems that it had failed to resolve. He concluded his introduction with six bullet points. They provide a useful summary of key issues of concern in current debates about risk management. Although not framed interrogatively they all contained implicit questions.

His points, and the implicit questions (*in italics*) that I will seek to answer, are:

1. Moral arguments surrounding the differing ‘rights’ of individuals, enterprises and the state to cause potential harm to third parties.
Why do moral arguments about ‘rights’ persist unresolved?
2. The case for a common Value for Preventing a Fatality or varying it according to the economic status of the potential victims and factors such as life expectancy and health.
Why can risk managers not agree on a common value for preventing a fatality?
3. The wide variations in approach to safety in the transport sector between road, rail, marine and air.
Why do governments and the media react differently to different causes of death?
4. The potential conflicts between a ‘Zero Tolerance’ approach to accidents and Cost Benefit Analysis.
Two questions:
Why do some institutions profess to be pursuing zero risk, knowing that achieving it is impossible?

*Why do some institutions pretend that their risk management problems can be reduced to a calculation in which **all** significant variables can be represented by a common metric?*

5. Societal attitudes and the influences on them. Strategies for communication and dialogue.

Why are societal attitudes and risk communication still seen as problematic after many years investigation?

6. The threats posed to technical investigation and prevention of accidents by over zealous criminal investigations.

Why are certain accident investigations, criminal or civil, seen as 'over zealous' by some and justifiable by others?

Turnbull observes (TEAMOS p3) that 'there would still be risk even if we applied all our resources to safety'. All his points and my questions listed above relate to the underlying problem of managing risk in a world in which absolute safety is not attainable. I will explore them with the help of a number of risk framing devices that I have found applicable to a wide range of risk management problems.

2 What are we trying to manage?

There are many ways in which one can categorize problems of risk management. Typing the single word 'risk' into Google produces hundreds of millions of hits. One need sample only a small fraction in order to discover unnecessary and often acrimonious arguments caused by people using the same word to refer to different things and shouting past each other. Figure 1, Types of Risk, I proffer as a fundamental typology in the hope that it might help to dispose of some unnecessary arguments and civilize others.

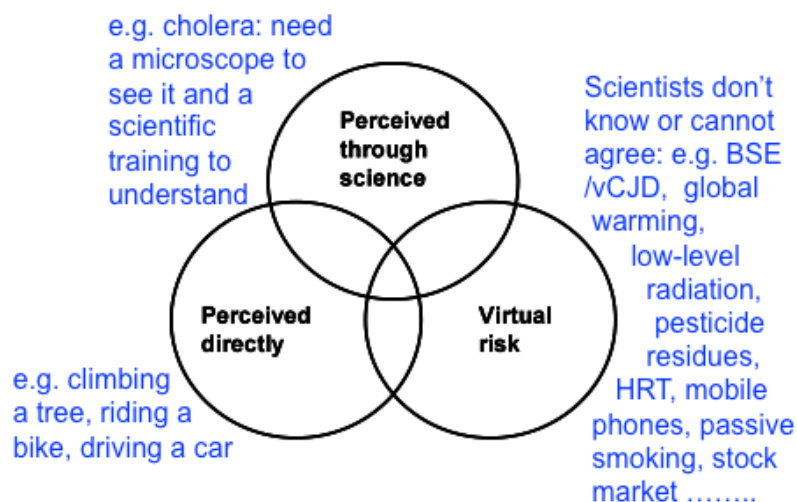


Fig. 1. Types of risk

We all routinely manage *directly perceptible* risks in everyday life. We do so using *judgement* – some combination of instinct, intuition and experience. We do not undertake formal, probabilistic risk assessments before we cross the road.

The circle labeled *perceived through science* contains most of the published risk literature. Here we find books, reports and articles with verifiable numbers, cause-and-effect reasoning, probability and inference. This is the domain of, amongst many others, biologists with microscopes, astronomers with telescopes, evidence based medicine, highway engineers and vehicle designers, bridge builders, epidemiologists, statisticians and insurance company actuaries.

The circle labelled *virtual risk* contains contested hypotheses, ignorance, uncertainty and unknown unknowns. During the seminar (TEAMOS p35) John McDermid observed that 'we have been talking all along as though we know how to quantify risk'. But if an issue cannot be settled by science and numbers we rely, as with directly perceptible risks, on *judgement*. Some find this enormously liberating; all interested parties feel free to argue from their beliefs, prejudices or superstitions. It is in this circle that we find the longest-running and most acrimonious arguments. Virtual risks may or may not be real, but beliefs about them have real consequences.

Moral arguments can get particularly heated in the zones of overlap in Figure 1. While we all might cross the road exercising our judgement others, institutional risk managers armed with statistics and different safety standards, often conclude that our behaviour ought to be managed to make us safer than we apparently choose to be.

Laws that criminalize self-risk, such as seat belt laws, and laws compelling the wearing of motorcycle helmets, and in some jurisdictions bicycle helmets, provoke fierce debate between civil libertarians and those who argue that sometimes even adults need to be compelled, in their own interest, to be careful (Adams 2006).

3 How do we manage it?

Figure 2, the Risk Thermostat, presents the essence of a phenomenon that Wilde called 'risk compensation' (Wilde 2001).

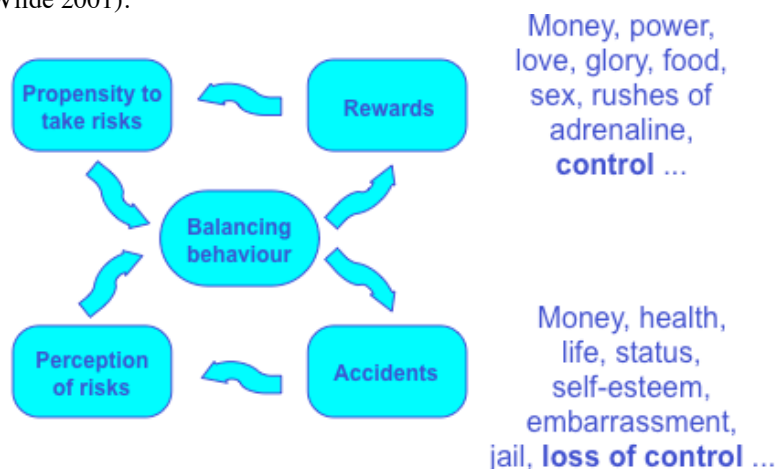


Fig. 2. The Risk Thermostat

Risk management involves balancing the rewards of actions whose outcomes are uncertain against potential losses. Figure 2 is a model of this balancing act. The model postulates that

- everyone has a propensity to take risks
- this propensity varies from one individual to another
- this propensity is influenced by the potential rewards of risk taking
- perceptions of risk are influenced by experience of accident losses – one's own and others'
- individual risk taking decisions represent a balancing act in which perceptions of risk are weighed against propensity to take risk
- accident losses are, *by definition*, a consequence of taking risks; the more risks an individual takes, the greater, on average, will be both the rewards and losses he or she incurs.

The model might be called cost-benefit analysis without the £ or \$ signs. It is a conceptual model, not one into which you can plug numbers and from which you can extract decisions; the Rewards and Accidents boxes contain too many incommensurable variables; our reasons for taking risks are many and diverse, and vary from culture to culture and person to person.

3.1 Institutional risk management and bottom loop bias

Frequently after an accident people chorus that risk was not managed properly. Not necessarily so. Culpable negligence must contend with bad luck as the explanation. If people take risks there will be accidents.

Figure 2 can help to explain the clash, referred to above, between individual risk managers and institutional risk managers. When I am managing my own risks while crossing the street or riding my bike I am performing the balancing exercise described by the Risk Thermostat. If I am late for dinner and I see my bus approaching on the other side of the road, I will risk shorter gaps in the traffic to get across the road to catch it.

But institutional risk managers frequently suffer from *bottom loop bias*. Their job descriptions commonly enjoin them not to have their judgement about what is safe or dangerous compromised by contemplation of the rewards of risk. Their job is to reduce accidents. Their role in commercial institutions frequently brings them into conflict with other departments, such as product development, sales and marketing who are more focused on the rewards of risk taking.

In the most affluent countries of the world there is a trend toward increasing institutional risk aversion. We all in our daily lives routinely manage risks by balancing perceived rewards against the perceived risk of accidents. But some of us (not me) are promoted to the ranks of the institutional risk managers. Their job is to reduce accidents, and then get them lower still. For them, one accident is one too many.

In many cases, in Britain the domain of education provides a good example, there is no effective top-loop counterweight. The unopposed demands for ever more safety result in significant opportunity costs. Interesting experiments in chemistry classes, field trips, games and sports are lost, not to mention the uncounted hours of productive teaching and research time devoted to the filling in of fatuous risk assessments.

In Britain at the time of writing one-sided institutional risk aversion and lack of trust are promoting defensive medicine, the practice of medicine in which doctors' fears of liability compromise the welfare of the patient. Medicine in Britain is now burdened with minutely detailed audit trails, risk assessments and expensive, unnecessary and sometimes risky tests. More widely, fear of liability, ever more stringent health and safety regulations, and the rising cost of insurance are leading to the abandonment of traditional fairs, fetes and street parties, the chopping down of many mature trees, the removal of hanging flower baskets and the banning of conkers played without goggles. Perhaps the single most worrying manifestation of risk paranoia in Britain is the Safeguarding Vulnerable Groups Bill that will require up to one third of the adult working population to be subject to continuous criminal-records vetting (Appleton et al. 2006).

3.2 Top-loop bias and weapons of financial mass destruction

At the time of writing (August 2008) the world is in a state of financial turmoil that might be attributed to *top-loop bias*. The 'subprime crisis' and the 'credit crunch' can be viewed as the consequences of financial risk taking in a context in which the rewards for playing successfully with other people's money are enormous. In a good year the Christmas bonus of a foreign exchange dealer or hedge fund manager can be enough to retire on for life. And if he has a financial 'accident' and loses his clients or shareholders a lot of money, the worst that is likely to happen is that he will need to find another job – while still retaining his earlier bonuses. On a more modest, but far more widespread scale, this distortion of incentives has led commission-hungry providers of mortgages to persuade large numbers of people to assume debts that they had no hope of repaying, especially in a climate of collapsing property prices.

The problem has been compounded by the hubris that confuses luck with financial genius, a condition nicely described by Nassim Nicholas Taleb in *Fooled by Randomness* (Taleb 2005). The financial instruments devised by the so-called financial 'rocket scientists' – famously labeled *weapons of financial mass destruction* by Warren Buffett – have become complex beyond the comprehension of most people trading them, and often beyond the comprehension of their devisers. Their apparent mathematical sophistication has led many who dealt in them to believe that they were safely within the scientific circle of Figure 1.

In reality they were in the Virtual Risk circle where the available numbers provided spurious support for judgments based on speculation, superstition and prejudice – and greed and vanity. A famous example has been compellingly documented by Roger Lowenstein in *When Genius Failed* (Lowenstein 2002). It is the story of the spectacular fall, in September 1998, of Long Term Capital Management, a fall that came close to bringing down the global financial markets. The principal 'geniuses' in this story were Robert Merton and Myron Scholes who shared a Nobel Prize for

Economics in 1997 for their discovery of ‘a new method to determine the value of derivatives’. So long as the assumptions embodied in their model held, so long as the phenomena they were modeling could be confined within the scientific circle of Figure 1, their genius trumped all competitors, and produced astonishing profits. But their vanity, arrogance and early success deceived them into believing that they had a formula for managing uncertainty.

3.3 What kills you matters

Figure 3 illustrates another way of classifying risks that can also help clear out of the way some unnecessary arguments.

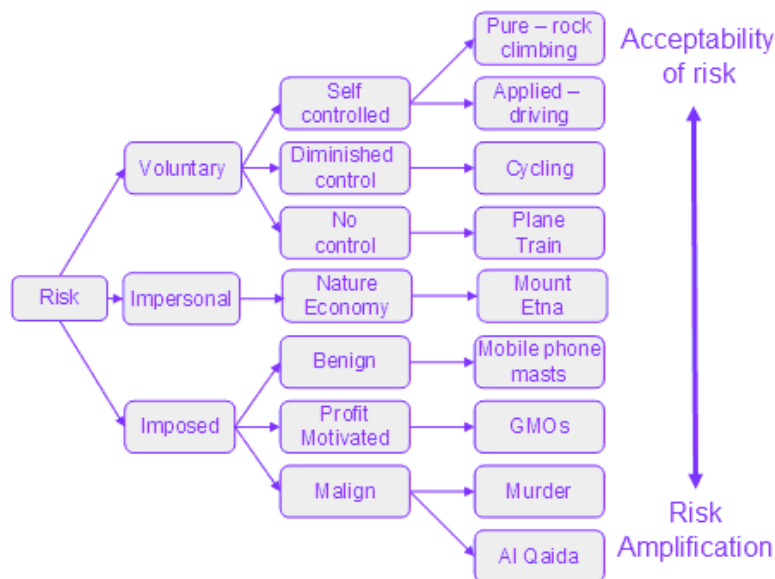


Fig. 3. Risk acceptability and risk amplification: what kills you matters

Acceptance of a given actuarial level of risk varies widely with the perceived level of control an individual can exercise over it and, in the case of imposed risks, with the perceived motives of the imposer.

With ‘pure’ voluntary risks, the risk itself, with its associated challenge and rush of adrenaline, is the reward. Most climbers on Mount Everest and K2 know that it is dangerous and willingly take the risk (the fatality rate on K2 – fatalities/those reaching the summit – is reported to be 1 in 4).

With a voluntary, self-controlled, applied risk, such as driving, the reward is getting expeditiously from A to B. But the sense of control that drivers have over their fates appears to encourage a high level of tolerance of the risks involved.

Cycling from A to B (I write as a London cyclist) is done with a diminished sense of control over one’s fate. This sense is supported by statistics that show that per kilometre travelled a cyclist is much more likely to die than someone in a car. This is a good example of the importance of distinguishing between relative and absolute risk. Although much greater, the absolute risk of cycling is still small – 1 fatality in 25 million kilometres cycled; not even Lance Armstrong can begin to cover that distance in a lifetime of cycling. And numerous studies have demonstrated that the extra relative risk is more than offset by the health benefits of regular cycling; regular cyclists live longer.

While people may voluntarily board planes, buses and trains, the popular reaction to crashes in which passengers are passive victims, suggests that the public demand a higher standard of safety in circumstances in which people voluntarily hand over control of their safety to pilots, or bus, or train drivers.

Risks imposed by nature – such as those endured by people living on the San Andreas Fault or the slopes of Mount Etna – or by impersonal economic forces – such as the vicissitudes of the global economy – are placed in the middle of the scale. Reactions vary widely. Such risks are usually seen as motiveless and are responded to fatalistically – unless or until the risk can be connected to base human

motives. The damage caused by Hurricane Katrina to New Orleans is now attributed more to willful bureaucratic neglect than to nature. And the search for the causes of the economic devastation attributed to the 'credit crunch' is now focusing on the enormous bonuses paid to the bankers who profited from the subprime debacle.

Imposed risks are less tolerated. Consider mobile phones. The risk associated with the handsets is either non-existent or very small. The risk associated with the base stations, measured by radiation dose, unless one is up the mast with an ear to the transmitter, is orders of magnitude less. Yet all around the world billions of people are queuing up to take the voluntary risk, and almost all the opposition is focused on the base stations, which are seen by objectors as impositions. Because the radiation dose received from the handset increases with distance from the base station, to the extent that campaigns against the base stations are successful, they will increase the distance from the base station to the average handset, and thus the radiation dose. The base station risk, if it exists, might be labeled a benignly imposed risk; no one supposes that the phone company wishes to murder all those in the neighbourhood.

Even less tolerated are risks whose imposers are perceived to be motivated by profit or greed. In Europe, big biotech companies such as Monsanto are routinely denounced by environmentalist opponents for being more concerned with profit than the welfare of the environment or the consumers of its products.

Less tolerated still are malignly imposed risks – crimes ranging from mugging to rape and murder. In most countries in the world the number of deaths on the road far exceeds the numbers of murders, but far more people are sent to jail for murder than for causing death by dangerous driving. In the United States in 2002 16,000 people were murdered – a statistic that evoked far more popular concern than the 42,000 killed on the road – but far less concern than that inspired by the zero killed by terrorists.

Which brings us to terrorism and Al Qaida. How do we account for the massive scale, world-wide, of the outpourings of grief and anger attaching to its victims, whose numbers are dwarfed by victims of other causes of violent death? In London 52 people were killed by terrorist bombs on 7 July 2005, about six days worth of death on the road. But thousands of people do not gather in Trafalgar Square every Sunday to mark, with a three minute silence, their grief for the previous week's road accident victims.

At the time of writing the British Government is proposing legislation that would permit the detention of terrorist suspects without charge for 42 days. The malign intent of the terrorist is amplified by governments who see it as a threat to their ability to govern. To justify forms of surveillance and restrictions on liberty previously associated with tyrannies 'democratic' governments now characterize terrorism as a threat to Our Way of Life.

4 Who is 'we'?

How 'we' manage risk depends on who 'we' are. Figure 4 presents in cartoon form a typology of cultural biases commonly encountered in debates about risk.

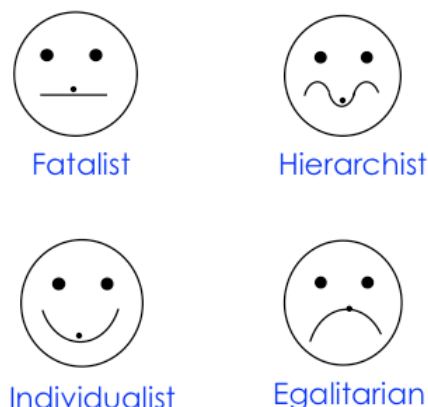


Fig. 4. A typology of cultural biases

These are caricatures, but nevertheless recognizable types that one encounters in debates about threats to safety and the environment. With a little imagination you can begin to see them as personalities. In a report for Britain's Health and Safety Executive (Adams and Thompson 2002) they are described as follows:

- *Individualists* are enterprising 'self-made' people, relatively free from control by others, and who strive to exert control over their environment and the people in it. Their success is often measured by their wealth and the number of followers they command. They are enthusiasts for equality of opportunity and, should they feel the need for moral justification of their activities, they appeal to Adam Smith's Invisible Hand that ensures that selfish behaviour in a free market operates to the benefit of all. The self-made Victorian mill owner or present-day venture capitalist would make good representatives of this category. They oppose regulation and favour free markets. Nature, according to this perspective, is to be *commanded* for human benefit.
- *Egalitarians* have strong group loyalties but little respect for externally imposed rules, other than those imposed by nature. Human nature is – or should be – cooperative, caring and sharing. Trust and fairness are guiding precepts and equality of outcome is an important objective. Group decisions are arrived at by direct participation of all members, and leaders rule by the force of their arguments. The solution to the world's environmental problems is to be found in voluntary simplicity. Members of religious sects, communards, and environmental pressure groups all belong to this category. Nature is to be *obeyed*.
- *Hierarchists* inhabit a world with strong group boundaries and binding prescriptions. Social relationships in this world are hierarchical with everyone knowing his or her place. Members of caste-bound Hindu society, soldiers of all ranks and civil servants are exemplars of this category. The hierarchy certifies and employs the scientists whose intellectual authority is used to justify its actions. Nature is to be *managed*.
- *Fatalists* have minimal control over their own lives. They belong to no groups responsible for the decisions that rule their lives. They are non-unionised employees, outcasts, refugees, untouchables. They are resigned to their fate and see no point in attempting to change it. Nature is to be *endured* and, when it's your lucky day, *enjoyed*. Their risk management strategy is to buy lottery tickets and duck if they see something about to hit them.

It was explained to the HSE that in the terms of this typology they were statutory Hierarchists who make the rules and enforce the rules. For the foreseeable future we predicted they could expect to be attacked from the Egalitarian quadrant for not doing enough to protect society, and from the Individualist quadrant for over regulating and suffocating enterprise.

5 Conclusion

Returning to Turnbull's list of unresolved issues and the questions that they contain, what, with the help of the risk framing devices set out above, might we conclude?

1. Moral arguments surrounding the differing 'rights' of individuals, enterprises and the state to cause potential harm to third parties.

Why do moral arguments about 'rights' persist unresolved? Individuals, enterprises and the state have different perceptions of the rewards and potential costs of risk. *Enterprises* are led by entrepreneurs, 'individualists' (top loopers) in the lower left quadrant of Figure 4 who tend to focus more on the 'rewards' of risk in Figure 2 than on the risk of 'accidents. The *state* is represented by 'hierarchists' in the upper right quadrant of Figure 4 who seek to manage risk by balancing its costs and benefits. 'Egalitarians' (bottom loopers) will complain about the callous profit-seeking activities of the individualists and the failure of the government 'the Hierarchy' to protect society. The rest of us can be found in all four quadrants but most are either 'egalitarians' protesting at the unfair distribution of the costs and benefits of risk, or 'fatalists' who are resigned to being unlucky but nevertheless continue to buy lottery tickets. The moral arguments remain unresolved because *there many moralities, and they are unlikely ever to agree*.

2. The case for a common Value for Preventing a Fatality or varying it according to the economic status of the potential victims and factors such as life expectancy and health.

Why can risk managers not agree on a common value for preventing a fatality? This question reflects a frustration common to most cost benefit analysts. The frustration is rooted in their assumption that there ought to be a common cash value for a life. Discovering it is proving difficult, they will admit, but find it they must. Otherwise their method is useless. So, despite decades of failure, they persist with their surveys and revealed preference studies in hopes of uncovering it.

Above I describe the various 'rewards' and 'accidents' in Figure 2 as 'incommensurable'. They are so for a number of reasons:

- a) Most people are simply incapable of reducing the pleasures of 'money, power, love, glory, food, sex, rushes of adrenaline...' to a common denominator.
- b) There is great uncertainty about what prevents fatalities – or other losses. In the realm of road safety, the effect of most accident prevention measures is greatly reduced, if not completely nullified, by risk compensation – the balancing act described by Figure 2; after the use of seat belts became mandatory more pedestrians and cyclists were killed by motorists enjoying an enhanced sense of safety (Adams 2006).
- c) Any 'value' that people attach to a risk is hugely influenced by whether it is perceived as voluntary or imposed. In the jargon of conventional cost benefit the analysts ask 'what would you be willing to pay' (WTP) to reduce your risk of death and 'what would you be willing to accept as compensation' (WTA) for an imposed increase in your risk of death. Figure 3 suggests that these answers will differ greatly – so greatly that cost benefit analysts usually do not ask the WTA question. The person being questioned is entitled to say 'no amount of money will compensate me for a particular imposed risk' and it takes only one infinity to blow up a cost benefit analysis.
- d) Within any given society there is no common value system. Individuals differ greatly in the value that they attach to any given risk or reward. *Assuming* that they could express these values in monetary terms, the average to which cost benefit analysis would reduce them would irritate almost everyone because the average would not represent their values.

*Cost benefit analysis settles no arguments – except amongst economists prepared to accept the unrealistic assumptions upon which it depends.*¹

3. The wide variations in approach to safety in the transport sector between road, rail, marine and air.

Why do governments and the media react differently to different causes of death? The reactions of both governments and the media reflect the range of risk acceptance and risk amplification described by Figure 3.

What kills you matters.

4. The potential conflicts between a 'Zero Tolerance' approach to accidents and Cost Benefit Analysis.

a) Why do some institutions profess to be pursuing zero risk, knowing that achieving it is impossible? The professed pursuit of zero risk is a defense mechanism. It is a paranoid response to the fear of the no-win-no-fee lawyer in an increasingly litigious society. It is unlikely to be much help. Accidents will happen. When they do the zero risk management plan will be closely examined, and assist the no-win-no-fee lawyer in identifying precisely where the human failure occurred.

b) Why do some institutions pretend that their risk management problems can be reduced to a calculation in which all significant variables can be represented by a common metric? Cost benefit analysis is an ineffectual comfort blanket. The senior management, the hierarchy, find numbers reassuring. They are precise (or have precise error bands) and can be produced as evidence that the management is in control of affairs. But in court they have turned out to be an 'aggravating offence'. Many years ago Ford did a cost benefit analysis of a proposal to make the fuel tank of a Ford Pinto safer. They calculated the cost of the safety improvement and the benefit of the lives and limbs that might be saved – using the then current values for lives and limbs. The cost benefit

¹ In TEAMOS p 40 Michael Jones-Lee observes that 'when one does an empirical willingness-to-pay exercise, one is asking people to wear a "self interested" hat, whereas when considering societal concerns, you are asking them to behave as citizens. I will say no more than that.' This is a remarkable concession from someone who for many years has been a leading defender of cost benefit analysis. The procedure is commonly called 'social cost benefit analysis' because it purports to capture non-market costs and benefits, sometimes called 'externalities'. Jones-Lee appears to be conceding that social cost benefit analysts cannot capture the social aspect of issues that they are called upon to resolve.

analysis concluded that the proposed safety benefit did not justify the cost. But a jury, after an accident, found this calculation so callous that they awarded unprecedented punitive damages.

Both the 'zero tolerance' approach and cost benefit analysis offer hostages to the no-win-no-fee lawyers.

5. Societal attitudes and the influences on them. Strategies for communication and dialogue.

Why are societal attitudes and risk communication still seen as problematic after many years investigation? They will remain eternally problematic. The 'risk communicators' are mostly to be found in the hierarchist quadrant of Figure 4. These are the risk experts who know, quantitatively, what the risks are, or pretend they know when the risks fall into the 'virtual' circle of Figure 1 – as most of them do. They are the legislators and regulators, and regulation enforcers. They despair of the 'irrationality' that they see implicit in the diverse responses to risk illustrated by Figure 3. They are frustrated by the phenomenon of risk compensation illustrated by Figure 2; extending sight lines should make roads safer – but motorists respond by driving faster. And they are bemused by the attacks from the different cultural biases illustrated by Figure 4; the egalitarians complain that the hierarchy is not doing enough to protect them, while the individualists complain that they are over regulating and suffocating enterprise.

There is no such thing as society.

6. The threats posed to technical investigation and prevention of accidents by over zealous criminal investigations.

Why are certain accident investigations, criminal or civil, seen as 'over zealous' by some and justifiable by others? Over zealousness is in the eye of the beholder. Those pursuing criminal investigations, commonly found in the Hierarchist quadrant of Figure 4, would rarely, if ever, concede that they were being over zealous; their job is to prosecute wrongdoers and thereby make the world safer. The different reactions to their works have been briefly described above.

An impressionistic view of media coverage of risk stories at the time of writing (September 2008) is that there is a consensus that the Hierarchy has been over-zealous in the pursuit of the risks posed by hanging flower baskets and the playing of conkers without goggles, and under-zealous in the regulation of hedge funds and providers of subprime mortgages. But it is a fragile consensus; *'over zealous' is a value judgment not universally shared.*

6 And finally

The drunk notoriously searches for his keys not in the dark where he dropped them, but under the lamppost where he can see. This is an apt metaphor for much of what is written on the subject of risk management.

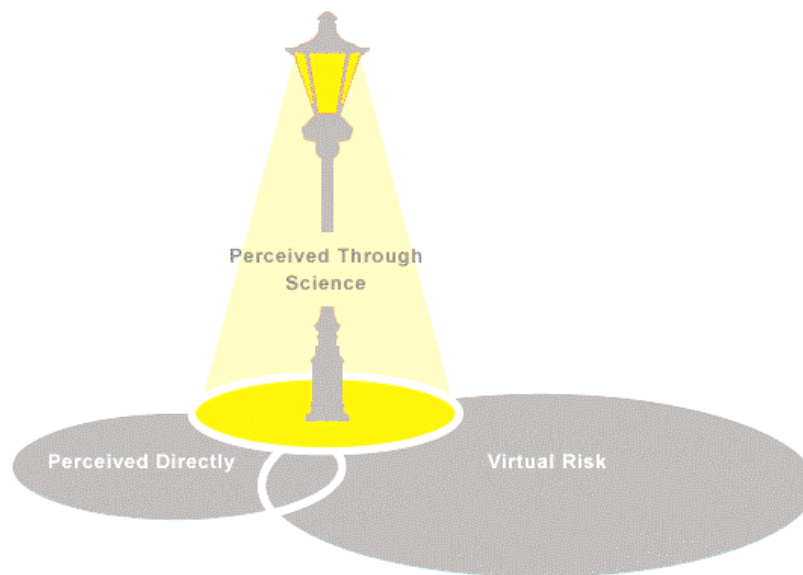


Fig. 5. Risk management: Where are the keys?

Lord Kelvin famously said, ‘When you cannot measure your knowledge is meager and unsatisfactory’ (words carved in stone over the entrance to the Social Science building of the University of Chicago).

This dictum sits challengingly alongside that of another famous scientist, Peter Medawar (1967) who observed, ‘If politics is the art of the possible, research is the art of the soluble. Both are immensely practical minded affairs. Good scientists study the most important *problems they think they can solve* [my emphasis]. It is, after all, their professional business to solve problems, not merely to grapple with them.’

Risk is a word that refers to the future. It has no objective existence. The future exists only in the imagination. There are some risks for which science can provide useful guidance to the imagination. The risk that the sun will not rise tomorrow can be assigned a very low probability by science. And actuarial science can estimate with a high degree of confidence that the number of people killed in road accidents in Britain next year will be 3,000, plus or minus a hundred or so. But these are predictions, not facts. Such predictions rest on assumptions; that tomorrow will be like yesterday; that next year will be like last year; that future events can be foretold by reading the runes of the past. Sadly, the history of prediction contains many failures – from those of stock market tipsters to those of volcanologists seeking to predict eruptions, earthquakes and tsunamis.

In the area lit by the lamp of science one finds risk management problems that are potentially soluble by science. Such problems are capable of clear definition relating cause to effect and characterized by identifiable statistical regularities. On the margins of this circle one finds problems framed as hypotheses, and methods of reasoning, such as Bayesian statistics, which guide the collection and analysis of further evidence. As the light grows dimmer the ratio of speculation to evidence increases. In the outer darkness lurk unknown unknowns. Here lie problems with which, to use Medawar's word, we are destined to ‘grapple’.

There is a distinction, frequently insisted upon in the literature on risk management, between ‘hazard’ and ‘risk’. A hazard is defined as something that could lead to harm, and a risk as the product of the probability of that harm and its magnitude; risk in this literature is hazard with numbers attached. So, relating this terminology to Figure 5, it can be seen that risk can be placed in the circle illuminated by science while the other two circles contain different types of hazard.

Typing ‘hazard management’ into Google at the time of writing yielded 120,000 hits; ‘risk management’, 36.6 million – 300 times more. But the number of potential harms in life to which useful numbers can be attached is tiny compared to the number through which we must navigate using unquantified judgement. The Kelvinist, approach to risk, with its conviction that everything in the outer darkness must be quantifiable, can only lead to self-deception. And following Medawar's dictum that we should confine our efforts to the quantitatively soluble, threatens to

divert attention from larger, more complicated, more urgent problems with which we ought to be grappling.

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