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Practices and problems in the management of risk redistributions

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The redistribution of risk across social groups is an important aspect of risk analysis. This article argues for a more general concept of risk redistribution across *any* significant categorisation, however, not just social groups. This includes the redistribution of risk across different kinds of harm, different kinds of failure mode and so on. These redistributions are connected by the way in which they all somehow threaten coping capacities that are adapted to specific past distributions: for example redistributions across failure modes threaten technological and organisational risk controls, whereas redistributions across social groups can threaten notions of fairness and social order. The purpose of the study described here was to investigate this general concept of risk redistribution as a managerial problem. It involved interviews with regulatory and consultancy staff, predominantly in offshore, maritime and railroad operations. These indicated that redistribution was a ubiquitous outcome of activity – and not one confined to discontinuous changes in technology or organisation. Yet, the management of this redistribution was not strongly institutionalised. It was mostly not embodied as an important concept in regulations, codes and procedures and it was not a product of risk assessment processes. But there was a considerable sensitivity to how both technological change and the practice of risk management itself produced redistributions, and extensive efforts were often made to deal with them in the informal domain.

Keywords: redistribution; coping; regulation; management; institutionalisation

Introduction

A generalised concept of redistribution

We most clearly associate the idea of risk redistribution with a change in the risk experienced by different social groups (Williams 1998). This social distribution of risk has been seen as becoming a central organising principle for society (Beck 1992) and a pivotal aspect of risk regulation and compensation processes (e.g. Hood, Rothstein, and Baldwin 2001; Jasanoff 1988). It seems to be a basic requirement for an acceptable technology that it avoids a 'manifestly unfair distribution of risks' (Leiss and Chociolko 1994, 33). It is a complication that fairness means different things to different groups (e.g. Douglas 1986, 6), but the general idea of a fair risk distribution is attractive as an important value in its own right (Renn 1992), reflecting the notion of distributive justice as a central criterion in public risk perceptions (Finkel 2008). There is a feeling, perhaps, that a capacity to manage risk redistributions still eludes

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us: fairness in the way risk is distributed is not well modelled in risk assessments (Slovic 1998), and our institutions sometimes seem incapable of dealing with risk redistribution, especially at local levels (Halfacre, Matheny, and Rosenbaum 2000). But we have a relatively clear concept of a risk distribution across social groups, and of the potential significance of social *re*distributions when introducing new technologies or practices.

The question addressed in this article is what value might lie in using 'redistribution' in a more general sense – as a redistribution of risk across any kind of significant categorisation, not simply social groups. For example, we have also come to see redistributions between high probability–low consequence risks and low probability–high consequence risks as being highly significant. Much of the controversy and interest in risk studies lies in the latter – in events thought to be rare but of catastrophic potential. Not only is the catastrophic potential seen as deeply troubling, but the low frequency denies or at least reduces the possibility of experiential learning (e.g. Perrow 1999). If there is a redistribution from high probability–low consequence risks towards low probability–higher consequence ones there will be a significantly different demand on organisational capacities to learn from rare events, to simulate and imagine events of which an organisation has no experience (e.g. Roberts 1990), and to maintain vigilance in the absence of obvious threat. Therefore, any significant change in the extent to which we bear high- and low-frequency risks brings into question our current capacities to manage risk.

Similarly, we can see redistributions among failure modes as being interesting and potentially problematic. For instance, the introduction of automation tends to remove human slips in performing control actions, but simultaneously introduces new failure paths, reduces the relevant experiential knowledge of human supervisors and makes failure patterns more complex (e.g. Bainbridge 1988; Lutzhoft and Dekker 2002). The same argument applies to redistributions among different categories of outcome – such as risks to safety and risks to security. Often these are thought to be in opposition, with a mitigation of one producing a shift to the other. For example, safety in commercial aircraft broadly benefits from accessibility while security benefits from *in*accessibility – so the accessibility of a flight crew to the cabin is good for safety but bad for security (Bennett 2002). Any change in the apportionment of risk between these two categories might make little difference to the aggregate level of risk we experience. Yet, it probably will still feel like a significant change and one that our systems and understandings will need to become adapted to. Such adaptation involves not least the re-ordering of responsibility and the locus of decision-making as the relevant risk objects become redefined (Hilgartner 1992).

There is also a case for analysing redistributions of risk across the categories that appear to be significant in society's risk perceptions: the factors found in 'psychometric' studies (e.g. Slovic 1987) and the patterns found in the cultural selection of risks (e.g. Schwarz and Thompson 1990). Ways of dying, kinds of control, degrees of voluntarism and so on are all categories that plainly matter to people and should be significant to risk managers. Thus we see, for instance, patients' preference for sudden death over permanent disability and a greater aversion to chemically induced cancers than acute microbially induced disease (Wiener 1997). If these categories matter then surely we should be analysing the distribution of risks across such categories, and how this distribution might change with the decisions we make.

In practice, the operative redistribution in a particular case may be a joint one. What might matter is that a new technology increases the involuntary risk experienced

by a particular social group. Or a new technology might create particular social groups that subsequently experience a new level of involuntary risk. Nonetheless the basic principle is to have a generalised concept of redistribution as a change in the loading of risk across any category system having some kind of social significance, not just a category system of social groups.

Terms cognate to redistribution

Several terms capture ideas similar to redistribution. The concepts of risk 'transfer' (e.g. Cross 1998; Graham and Weiner 1995) and 'risk-risk analysis' (e.g. Viscusi 1996) are well known. Thus, for instance, banning pesticides on risk grounds potentially introduces a range of countervailing risks – from substitute compounds, increased natural pests, increased levels of natural toxins and so on (Gray and Hammitt 2000). The risks of pathology are merely exchanged for the risks of treatment when we speak of 'iatrogenic' effects (e.g. Wiener 1998). And behavioural influences often mean that a measure to reduce a risk merely provokes a response that undermines its own effectiveness – for example through the 'lulling' effect (Viscusi 1984) or risk 'homeostasis' (Wilde 1982). The notion of risk 'migration' (Alcock and Busby 2006) is similar, referring to the way that risk transfers appear to be organised into more general processes in which scientific knowledge and social response evolve over time. Risks do not so much dissipate as move from one form to another.

Such risk transfers, exchanges and migrations generally involve risk redistributions, but the central aspect of redistribution specifically is that it involves changing the way risk is distributed over some relevant kind of category structure. This is suggested in Graham and Wiener's (1995) typology of risk transfers which refers to potential changes in the type of risk and the risk bearing population. The focus of interest with redistribution is less the process of transfer and exchange and more the experience of a change in the loading on these categories. For example, the use of flame retardants in furnishings, which subsequently come under suspicion of being toxic, could be construed as a risk transfer. It involves exchanging a risk associated with fire for a risk of toxicity. An interesting consequence of this transfer is a redistribution of the risk borne by householders across different levels of agency. On face value these risk bearers have at least some agency in the fire risk, but virtually none in the toxicity risk, so the effect of introducing flame retardants is to increase the un-chosen amount of risk in their lives while reducing the chosen amount. This redistribution of risk loadings across a significant categorisation, of the chosen and un-chosen possibilities experienced by a certain population, is an important aspect of the risk transfer.

An organising framework

These very different kinds of redistribution – across social groups, types of harm, failure modes, broad categories of frequency – lack any obvious connection. But they all threaten coping capacities of some kind. Redistributions across social groups have implications for the general social order and the public acceptance of technologies and institutions. Redistributions across failure modes have implications for the effectiveness of technical risk controls. Redistributions across the indistinct boundary between high probability–low consequence and low probability–high consequence risks have implications for how organisations learn and maintain vigilance. All such redistributions are

potential threats to coping capacities that have become adapted to an existing category system and an existing risk distribution across it.

Figure 1 divides the problem of risk management into choice and coping. Choice is broadly concerned with discrete changes in the world – such as introducing a new technology – that bring about marked changes in the risk that people experience. Coping, on the other hand, is broadly concerned with dealing with the risk that remains after these choices are made. This distinction is only an approximate one, since 'coping' clearly involves making choices, and issues of coping will influence processes of choosing. But the idea is to distinguish the set piece decision events, like choosing a new technology or choosing whether to accept its risks, from the day-to-day business of managing or putting up with a risk. It is broadly the kind of coping that Douglas (1986, 27) refers to, and what Luhmann (1993, 43) describes as the 'irreducible residue after every counteractive effort at orderly execution'.

The process of choice naturally emphasises information that helps decision-makers make comparisons. It, therefore, stresses aggregating risk assessments of the traditional kind. The more complex the output of the risk assessment the harder it is to compare alternatives in the choice process, so a risk assessment that produces risk levels experienced separately by different groups makes choice difficult if one

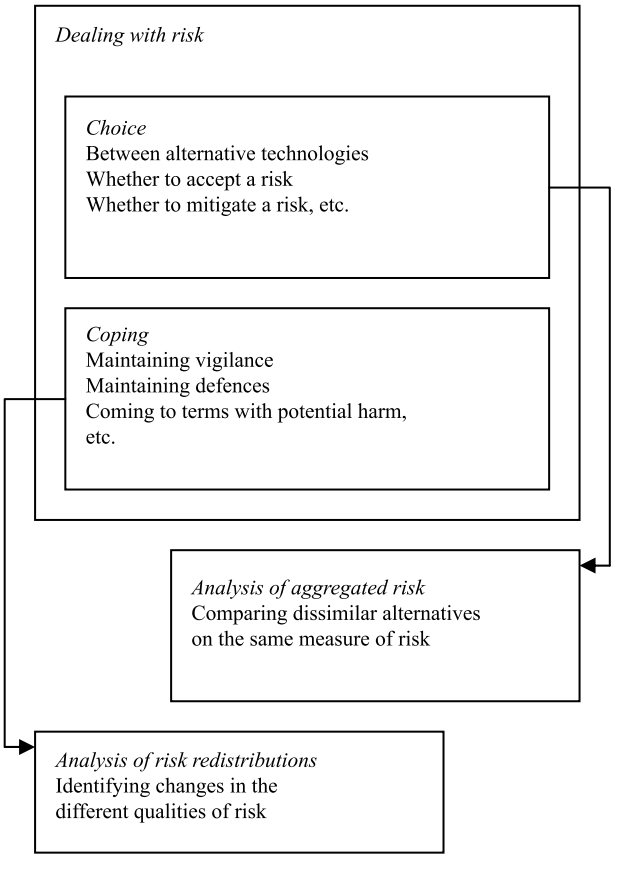

Figure 1. Choice versus coping.

alternative does not dominate another. This naturally leads to the preference for a probabilistic treatment over a contextualised one (Thompson and Dean 1996). Processes of coping, on the other hand, naturally emphasise changes in the nature of risks as much as their level. In particular, they need information showing how capacities to deal with risk have become conditioned on risks being distributed towards or away from certain categories – and showing how a new technology can produce a redistribution over those categories.

It also seems reasonable to link this coping to different systemic levels. For example, if risk is redistributed over different failure modes this may threaten the technical controls in a system. At the other extreme, if risk is redistributed over different social groups, for example when hazardous facilities are sited in particular locations, this may threaten the existing social order and the toleration of one group's activity by another. Figure 2 suggests a number of systemic levels that are likely to be relevant: the technical system, the social organisation that runs the system, the regulatory system that scrutinises social organisations and the society as a whole in which all this operates. At the boundary between each systemic level a certain amount of risk is coped with, in one way or another. We eliminate it, mitigate it, or manage it, accept it or simply resign ourselves to it. Redistributions across different category systems threaten coping capacities at these different boundaries. Redistributions across failure modes largely threaten coping at a technical level, for example, while those across social groups largely threaten coping at a societal or perhaps regulatory level.

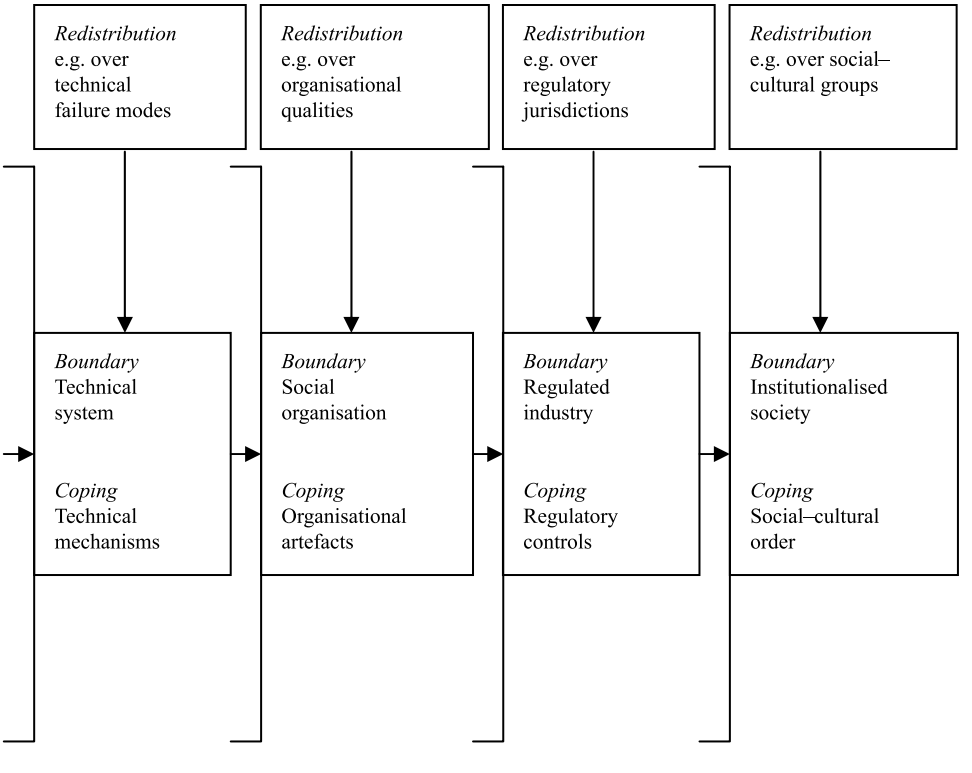

Figure 2. Coping at different systemic levels.

Method

The aim of the study was to address two questions: (1) what kinds of redistribution (potential or actual) do we see as being significant and problematic, and (2) how are they understood and managed? These questions were tackled in the context of regulatory and consulting organisations operating in certain hazardous industries, particularly offshore hydrocarbons production, railroads and maritime operations. These represented areas of relatively stable technological understanding where it was reasonable to assume there was historical experience of redistributive issues. The basic research design was an inductive, grounded study. The analysis was managerial rather than economic, and it was not the aim to measure redistributions but instead to analyse how they created problems for risk managers. This led to a process of data collection that was based on partially structured individual and group interviewing, and a qualitative approach to the analysis.

Data collection

The data were collected in interviews with 38 individuals, of which all but nine participated in group interviews of between two and seven people. Of the 38, 24 were staff in regulatory agencies, while the remainder were staff in technical consultancies. This was a convenience sample and the participants were self-selected, having expressed an interest in a short, written briefing on the study. Each interview was minimally structured. The informants were given an initial briefing in which the aim of the study was explained. Informants were asked to introduce themselves and describe their responsibilities. They were then asked to talk about cases of redistribution in their experience and as far as possible we relied on their unprompted narrative. These cases included conjectured and hypothetical redistributions as well as actual events, and it seemed important to include these because in any study on risk it is the interpretation of a potential for harm that constitutes risk, rather than the actuality of it. For example, one hypothetical case involved the real-time management of a crisis in a hydrocarbons installation, and the possibility that – in the event of an oil release – the release could be ignited, reducing risk to people off-site but increasing it to people on the site. Cases like this allowed interviewees to talk about how they perceived some of the problems involved in redistributing risk among social groups. Occasional interjections by the interviewer were used to prompt description of redistributional issues that the informants had hinted at but not fully explained. As far as was possible, then, the data can be regarded as the informants' conversational interpretations of their experiences and beliefs, prompted and organised by the general concept of risk redistribution.

Data analysis

The analysis broadly followed grounded, inductive approaches (e.g. Glaser and Strauss 1967) in which theoretical understanding is developed from a reading of the data, rather than being fully developed in advance and then tested against the data. There were a number of departures from a strictly grounded approach – for example in convenience sampling rather than theoretical sampling (Glaser and Strauss 1967, 59). That is, the choice of informants was mostly determined by who was prepared to be interviewed, not by a developing theory of who would be most informative. But there was an adherence to the general notions that the fundamental operation of

analysis is to discover classes and their properties (Schatzman and Strauss 1973, 110) and to specify differences among and within classes, as well as similarities (Strauss and Corbin 1990). The procedure was as follows:

(1) To isolate fragments of the informants' narratives that had some bearing on our two research questions. This involved selecting self-contained parts of the interview notes or transcripts that in some way referred to a risk redistribution in the judgement of the researchers (not the informants).
(2) To find generalised categories for these fragments that provided relevant ways of grouping them. The choice of categorisation is inevitably subjective, but the categories form sub-headings for the 'Findings' so that they can be assessed for their meaningfulness.
(3) To group these categories in a way that addresses the research questions. For example, one category was of descriptions about redistribution processes that arose from fixed standards, and items under this category helped address the first question about what kinds of redistribution are seen as being significant. Another category was of descriptions about the informal ways of treating redistributive effects, which helped address the second question about how redistributions are managed.

As the process was inductive, the category headings emerged during the analysis and at some point reached a point of 'saturation' where new fragments stopped giving rise to new categories. This method, in common with most qualitative data analysis methods, is not an objective, confirmatory one. The data are not used to test specific hypotheses, and the findings do not simply confirm or refute the framework proposed in the previous section. Justification for such methods can be found in various texts (e.g. Berg 1989; Bryman and Burgess 1994; Mason 1996; Walker 1985). The process is vulnerable to the problem of treating categories as more concrete than they really are, forgetting the context in which categorised items occur (Mason 1996). It is also important to remember that our explanations will be critically dependent on the basic assumptions (Miles and Huberman 1984, 145), outlined in the last section, which in this case centre on redistribution as a managerial rather than economic or more broadly social problem. Nonetheless the process tends to produce richer, more complex insights than confirmatory research – and is suitable when there is little in the way of definitive theory. It is also especially suitable when the problem of interest concerns social interpretations as much as objective phenomena. The outcomes were validated in terms of their ability to 'describe reality with a good fit' (Gummesson 2000, 93) by providing them, in the form of a draft of this article, to the six study sponsors in the participating organisations. All but one made substantive comments which led to refinements in the detailed claims.

Findings

This section is organised in two main parts:

(1) the kinds of redistribution that are described by regulators and consultants; and
(2) the ways in which redistribution is understood, analysed and managed.

The sub-headings under each main part reflect the categories obtained in the analysis.

What kinds of redistribution are described?

Redistributions from trade-offs

Many of the examples of redistribution that emerged in the interviews arose from trade-offs, transfers or countervailing risks of the kind that we tend to regard as commonplace. Interviewees often saw redistribution as involving particular events in which the effort to manage one risk produced other risks of a different character, possibly involving a different risk bearing group. Such trade-offs included:

- The trade-off between allowing a system to operate in a degraded mode, which incurs a greater risk of catastrophic failure, and intervening in the system to fix it, which might incur other risks, such as exposing workers to hazardous conditions.
- The trade-off between having high levels of hazardous inventories at one location, which incurs a high risk at that site, and having large numbers of transport movements, incurring risks in a transport corridor.
- The various trade-offs involved in automation, typically between avoiding basic operator error on the one hand, and losing the human skill needed when the automation fails, on the other. For example:

> In automated engine rooms there are less staff so there's a fatigue problem of maintaining watches. [Also] it appears safer as automated machinery but then if you have a fire you only have two people to fight it instead of ten. [Also] automation brings in more failure modes because you can't do anything about developing problems – you can't intervene at the fundamentals.

- The trade-off involved in operating systems at higher rates, increasing risk to operators but reducing risk to maintenance staff. For example:

> If trains went faster you could use the increase in speed to get more white space in the timetable which would make track workers safer [but] should trains go faster, increasing the risk of an accident?

Some of these trade-offs involve relatively small, short-term redistributions. Finding a defect in a hazardous installation means that assessments of risk to a relatively large group can suddenly rise, although normally only by a small increment. Asking employees to intervene in the installation to fix the defect then means they bear an additional increment of risk, but only for a short period. Some of the trade-offs involve redistributions that are longer-term but probably subside over time. Moving from a manual control system to an automated one redistributes risk over a different set of failure modes, and during a period of familiarisation might raise the risk associated with some failure modes considerably. But as experience is gained with new kinds of system this risk is expected to fall. Some of the redistributions are more or less permanent. Reducing hazardous inventories and increasing transport movements constitutes a long-term redistribution of risk from a single site to a transport corridor. Sometimes multiple trade-offs are implicated in the same action. For example, in trading off risks of allowing a degraded installation to remain in operation against risks of intervention you might be both trading off risks to a general public against risks to a workforce, and risks of environmental harm against risks to safety.

The notion of a 'trade-off' provided actors with a general explanation how risks were redistributed largely as a side effect or by-product rather than by intention. It

allowed them to attribute the agency behind redistributions to the world beyond their influence. In one sense, situations like that in which risk managers must trade-off risks of leaving a hazardous installation in a defective state against risks of exposing workers to a short-term hazard are problems of their own making. They have chosen methods of production that create situations like this. But representing these situations as 'trade-offs' emphasises their quality as givens, not choices.

Redistributions from processes over time

Risk was also redistributed as a result of various processes occurring over time:

- Longer-term physical processes, such as the gradual, mechanical degradation of large structures, redistribute risks over different failure modes.
- Longer-term societal processes, such as the increasing desire for 'closure', create new risks for particular groups of workers – such as those who have to recover bodies in war zones and oceans. For example:

> In older times the vessel and bodies were consecrated at sea … but [there are] now very emotive campaigns where people want bodies back … the language of 'closure' … but we had an incident where two divers died trying to recover one body.

- Medium-term technological developments, such as the increasing scope and capability of technical systems, redistribute the agency as well the failure mode of risk over time. For example, when adopting engineering analysis software:

> You transfer risk from the company responsibility point of view to the software designer. This transfer looks great to the design company but designers don't understand the assumptions. For example we've accepted the FEA of doors and ramps although surveyors in the appraisal office are not familiar with the software.

- Medium-term organisational changes, for example the shift from operation to decommissioning in nuclear power stations, change risk distributions across failure modes and sometimes different social groups.
- Short-term, planned changes in activity also change the distributions of risk experienced by people over time. For example, in the offshore industry, people are sometimes engaged in production in hazardous places and sometimes resting in much less hazardous accommodation areas. Some groups enjoy relatively low risks in a relatively even pattern – for example, those whose job is to work in accommodation areas. Others experience higher risks and higher variations from one time to the next. Informants occasionally talked about the notion of 'dynamic' risk assessment practices that reflect this constant shifting of levels and types of risk as activity develops over time.
- Irregular and essentially unpredicted redistributions of risk across failure modes, places and groups occur when defects and deficiencies arise. Obviously defects can come into being and become noticed at quite different times, so there is a sense in which there can be local risk 'peaks' that are unknown at the time. One interviewee talked about the example of automatic train doors, and how problems became evident with the functioning of protective devices associated with them. Such problems often cannot be corrected technically until the next generation of

design is available. Operators therefore rely on procedural controls instead and this naturally redistributes risk across different failure modes.

As with trade-offs, processes over time as a source of redistributed risk are generally seen as by-products or side effects – not intentional outcomes.

Redistributions from changes of perspective or subject

Once risk is accepted as being subjective, a matter of possibly idiosyncratic knowledge, or a social construction, redistributions accompany changes in the actor that is experiencing or observing a risk – not just changes in the objective state of the world. An example in the data concerned offshore installations that were sold by large oil producing companies to smaller firms that might operate only a very few installations. The risks associated with a specific installation are, for a major operator, relatively small constituents of a large portfolio. For the smaller operator they can have a much greater significance as a major loss on an installation operated by a single-installation company is an existential risk rather than a mere quantitative risk to reputation or profit. Thus, change of ownership can involve a significant shift in the way a given potential for physical loss constitutes a risk for the risk bearer:

> New entrants are actually investing much more heavily than the big operators in restoring and updating … [Company X] took over a big platform which had a safety case but it was in a poor state and [Company X] took [Company Y, the previous owner] to court for misrepresenting the state of the platform, which was decrepit … [Company X] spent the last two year's profits bringing it up to scratch. The new entrants can't afford to have one of these collapse because it's such a large part of their business – [Company Y] and [Company Z, an established operator] do a cost benefit analysis and say 'let it collapse'.

We have got used to the idea of risk as an 'overlay' on the world (Jasanoff 1993) rather than a property of it. Different actors naturally have different overlays so come to different views of the significance of what seems to be a given risk. But these differences are not *just* differences in perspective, and they can have highly consequential results. When a change of ownership produces a significant difference in the meaning that is attached to a set of risks around an installation, this is likely to produce a substantive change in the way the risks are managed.

Redistributions from standards

There are situations in which a fixed standard can redistribute risk. An example in the data involved electricity generating capacity that was operating without slack during winter when a specific installation became defective. Taking such an installation out of service – to maintain safety standards – would lead to a shortfall of capacity and increase risk to vulnerable groups. Unless a decision were made to reduce safety standards there would be a redistribution of risk towards these vulnerable groups:

> We have standards in how safe a reactor has to be … if we have to shut down with our regulatory powers because it currently doesn't cope with a 1 in 100,000 accident … then you hit a fuel crisis, for example in winter electricity demand comes close to capacity, and if stations are out of service then [there is] the spectre of power cuts and people die in power cuts. So do you keep the reactor offline to avoid the 1 in 10,000 risk and cause power cuts which cause people to die?

A similar case arises when a train operator wants to retain a sub-standard or defective vehicle in operation, on the grounds that taking the vehicle out of operation would force a certain number of passengers on to the roads where they would suffer higher levels of risk. Accepting this argument would legitimise a reduction in standards. But the consequence of maintaining standards, on face value, is a redistribution and, in this kind of case, an accompanying increase in the aggregate risk level.

Moreover, standards or norms that are intended to make risk distributions more uniform have the potential to undermine attempts to change the general risk level. An example in the data had to do with the way in which reference to good practice is a part of testing whether risks are 'as low as reasonably practicable'. Notions of good practice, best practice or the state-of-the-art naturally lead risk managers and regulators to compare installations or systems of similar types, and use the example of better installations to make demands on the less good. This helps avoid highly unequal distribution of risk among such installations, but a side effect is the way this can discourage firms with multiple installations from innovating and improving their installations over time. If they improve one installation they create a standard that can be used to criticise the others:

> You have to be conscious that the very first question that is asked when you suggest an improvement is 'what has the other asset done?', because if you go and implement acoustic gas detection … you are setting a precedent, so you've got to talk to other assets of the company and ask if they've considered it, and if the answer is 'no' why not? So you need to go back and reconsider it and the decision is sometimes made higher up: 'oh I don't want you to be doing that because it is setting a precedent'.

Redistributions from management and regulatory forces

In most interviews, the interviewees described various aspects of risk management processes that had the potential to produce redistributions. For example:

- Redistribution can occur towards risks that are socially problematic to report. Certain classes of risk are likely to be under-reported – for example those involving deliberate violations – because they are objectionable. These classes are therefore likely to receive less attention, and possibly become more significant as a result. The very fact that they are under-reported made it hard for the informants to know in any definitive sense just how big a problem this was.
- Prescriptive approaches can redistribute risk into events outside the design basis of a system. Where risk regulation is largely founded on the idea of controlling a pre-determined set of event types, or on conforming to pre-determined standards, it is possible that risks outside this set, and beyond the compass of existing standards, are increased while those within the set are reduced.
- Blanket or uniform approaches to dealing with risk can redistribute risk across different locations. An example we were given was that of licensing or 'pre-licensing' a particular design of nuclear installation, irrespective of its site, which would not take account of the particular features of that site, and would therefore create an uneven distribution of risks across multiple sites. The solution was to set up a 'generic site' that encompassed the most demanding conditions found across all candidate sites, and then examine the effect of any residual local idiosyncrasies.

- Accidents that are salient generate political imperatives that can then bias risk management priorities. Interviewees described how major accidents often drew the attention of politicians, and often concentrated effort on managing the newly prominent categories implicated in the accident. Risk then became shifted to other categories. For example, high levels of inspection of small maritime passenger vessels were required by a ministerial target following the *Marchioness* disaster. It seems likely that this drew resources away from other areas and that risk might have been redistributed into them.

Cases such as these redistribute risk because risk managing activity is in some way disproportionate to their agreed risk level. In two of the researched industries there was a debate among regulators about whether to give all the firms in an industry equal attention, or to give most attention to those who had the most accidents. A risk-based approach indicated the latter, but the expectation was that this would be seen as objectionable from those receiving the most attention. It might also be seen as favouring large, organisational actors, for example:

> If you're doing things purely on a risk basis you'd leave e.g. [large shipping operator] alone for five years and stick your best surveyors in fishing villages. But if even a small passenger vessel then turns over there'd be an outcry. Yet in terms of annual losses, it's on fishing and leisure craft. You could save more lives by leaving the big boys and going after fishing and leisure.

Biases in managerial attention seem inevitably linked to notions of social acceptability. There were also examples of where this attention itself could be unhelpfully redistributive. One informant described how, when high-risk activities received more regulatory attention, there was a tendency to drive firms or individuals into the informal economy where they were more at risk. In another example, an interviewee described how workers' shift patterns were organised to minimise risk when they were at work on hazardous installations, but this tended to merely shift risks into workers' domestic life and travel between home and work. Thus, managerial or regulatory action can redistribute risk, both by adding to the risk of under-managed activity and by moving activity into the under-managed domain.

How are redistributions understood, analysed and managed?

Redistribution information is not a product of risk assessments

The risk assessment processes described by interviewees, and the sample risk assessments they showed, did not produce information about risk redistributions as an analytical output. The product of the risk assessments was not an understanding of how a technology was going to redistribute risks across social groups, failure modes or different kinds of harm. For example:

> From a safety assessment point of view it doesn't really make any difference what category the person is in. Just the question: would this failure would this hazard injure or kill anyone or not? We don't generally distinguish between what category the person may come into.

In certain respects, assessment practices began to approach a redistributional analysis. Most obviously, the practice in various industries of separately calculating the risk

exposure of different social groups – such as employees, customers and bystanders – gives distributional information. For example:

> People who are exposed to risk are divided into the general public, the passengers, general public are external to the railway and don't gain any benefits from it, people who use level crossings, live by the railway, you've then got the passengers who pay a fare to travel by rail, they gain benefit from using the railway, and they are exposed to higher level of risk … the third group are the staff and the contractors, so these are people employed by the railway, again, quite a benefit and higher risk.

But this was hardly a redistributional analysis, since it did not show how the distribution over different groups or types changed with the introduction of a new technology or system, or how the distribution of exposures compared with the background risk experienced by the groups in question. It could not, therefore, provide any understanding of whether the new technology threatened existing coping capacities.

There were inevitably many points in the risk assessment processes where categories of one kind or another were introduced, and the risk loading on each category calculated, only for this distribution to be discarded at the next stage of analysis. Distributional information was used to assist the assessment process, but was not its product. For example, exposures were calculated for different social groups because that was the way accident statistics were recorded, and preserving the same categories in the risk assessment facilitated the use of historical records as data:

> In the railways the major measurement is done by the HMRI annual reports … And they categorise types of accidents and the people to whom those accidents occur. And that categorisation is the basis for, because it gives you data, the basis for risk assessment. Passengers, workers, neighbours, is the standard one.

Similarly, the risks borne by specific vulnerable groups (such as disabled passengers and track workers at night) were calculated, but only to find maximal exposures, not to identify changes in distribution. In the same way, categories of failure mode were often used in o rder to assist the process of identifying risks, not because it was the distribution of risk across these failure modes that was seen as the interesting outcome.

Thus, it would be wrong to say that formal, analytical processes were blind to risk redistributions, since they certainly draw on them as inputs. But they disregarded redistributions insofar as they did not treat them as significant output. And even in the few cases where the output did indicate some kind of distribution – generally across three or so social groups – it did not do this because there was a view that *re*distributions were generally important.

Redistribution is not institutionalised more generally

Interviewees often referred to various other formal devices of risk management, including their own organisation's procedures, the legal requirements imposed on them and regulatory agencies' publications. They mostly claimed there was little reference to redistribution in these.

Again it would not be true to say that redistribution is ignored. Some operating organisations made specific distinctions that involved redistributions, for example:

> Companies vary. Some are much more clued up, and for example separately prioritise normal and low consequence–high probability risks because they recognise they're different.

Regulatory guidance also deals with particular kinds of redistribution. For example, one guide (HSE 2001) refers to the possibility of risk transfers and trade-offs, the need to ensure that individuals are adequately protected and the relevance of unfair distributions of risk – for example in the process of siting hazardous installations. It is said that 'society can be seized by hazards that pose, on average, quite low levels of risk to any individual but could impact unfairly on vulnerable groups'. There are statements that risk assessment procedures should attach more weight to hazards that give rise to 'societal concerns, such as the potential to affect future generations', and that more stringent measures are indicated for risks that are irreversible in some way. Both indicate a sensitivity to particular kinds of redistribution. In another guidance document there is an explicit reference to redistribution:

> Societal risk may be redistributed in many other ways: for example through time, so that less risk is borne now, but more by some future generation. Or one kind of risk may be substituted for another. (HSE 1992, 3)

A further piece of guidance (HSE 2006) also refers to distributions of risk over time, saying:

> The variable risk rate due to normal operation is generally averaged out over a year, but brief periods of substantially higher risk than average should be reviewed separately … if there is a change in the plant operational state for a short time, due to say maintenance activities, or if some control measures are removed to allow a job to be done, the plant must still be adequately protected.

Some informants argued that an aversion to large accidents is built into regulatory thinking, suggesting a strong sensitivity to technologies that might reduce risk in aggregate but redistribute high probability–low consequence risks into low probability–high consequence ones.

But, although it would not be true to simply say that redistribution is ignored at an institutional level, the idea of redistribution did not arise as a general concept. References to distributional issues were specific and isolated and do not indicate that *re*distribution might in any sense be problematic. The notion of a systematic process for looking at redistribution did not arise.

A similar inference could be made about the principle of managing individuals' risk exposures. For example, the wide variations in exposure within a population were plainly recognised:

> Some people might spend a little bit of their time on the track, designers for example at the beginning of the project would go and walk the track and that is it. But some people spend all of the time on the track and some people spend absolutely none of their time on track, so it is very difficult.

Regulatory interviewees typically talked about the concept of an individual's 'bucket of risk':

> If someone's bucket is full then we're more careful about imposing new risk.

Thus, in a sense, current assessment practice aims to understand risk distributions right down to the individual level. Generally, however, this was done with the aim of finding the most exposed individual, not finding the distribution and redistribution across many individuals – and whether it was fair, for instance, or reflected levels of benefit. Thus:

> Creating groups just gives you a heading for which to estimate or calculate exposure or collect the data for exposure, and there is no meaning other than that.

Having a concept of managing for worst cases, or most exposed individuals, is not the same as having a concept of managing redistributions.

Redistribution is frequently recognised in specific instances

The absence of a general principle of redistribution in the normal analysis of risk did not mean there was an insensitivity to particular redistributions in particular situations. All the accounts we gave in the previous section indicate a strong awareness among the informants of the redistributive consequences of the activities they were involved in. There was a strong sense of how some kind of balance needed to exist in the way risk was distributed, for example:

> You reduce risk to passengers but you need to inspect the track more often so you put more people on the track – you increase risk to staff, but you look at different individual risk to [different] parties and they should balance out.

There was also a clear recognition of the contested nature of certain redistributional problems: for example, whether less should be spent on preventing trespassing on the railway – by people intending suicide or vandalism – in order to fund risk reductions elsewhere. The apparent voluntarism of risk bearing could be an important categorical distinction, not just because of its moral significance but because of the presumed determination behind voluntary acts. For example:

> Trespassers aren't all equal, you can get determined trespassers versus accidental ones and measures to keep them off the railway would be grossly disproportionate.

Thus, although there appeared to be little in the way of an analytical or institutional framework for taking account of distributions and redistributions of risk, interviewees were sensitive to their occurrence and the issues of coping that they raised.

Interviewees were also plainly sensitive to the redistributional insensitivities of their own processes. For example, one talked about how the emphasis on environmental clean-up of hazardous emissions produces an under-emphasis on the safety risks associated with the cleaning up process itself. Another talked about the danger of redistributing safety risks into welfare losses, such as when a galley is removed from an offshore installation. This looks good in terms of safety, but poor for welfare. Another interviewee talked about how duty holders sometimes argued that hazardous occupations were made more acceptable when the occupation was distributed over several individuals, each working only for a short period of time. This 'salami slicing' was seen as being fundamentally questionable and ultimately unlawful:

> We say that even if specific individuals are less exposed, the gross exposure is still the same. And you can't have a short period of light dose followed by a period of high dose.

> [There is] case law from [a specific location] where workers were exposed to an unguarded edge for a short time – but the contention that this was acceptable because exposure time was short was thrown out by the courts.

In a sense the redistribution is a positive one because it transforms a large exposure for one actor into a smaller exposure for several actors. But it amounts to diluting risks rather than managing them in any positive sense, and holding low exposures over long periods to be equivalent to high exposures of short periods is regarded as being far from axiomatic.

Redistribution is often handled in the informal domain

The general lack of an institutionalised concept of redistribution, but the high levels of individual understanding and sensitivity to particular redistributive issues, takes us onto a third theme from the interviews: the preference for informal means of handling redistributions. When interviewees talked about the processes of dealing with redistributions they claimed that it mostly happened in the informal, negotiated, possibly political domain rather than the formal one. Very often potential redistributions crossed organisation boundaries, for example the jurisdictions of regulatory agencies. Interviewees talked about managing these by setting up cross-departmental 'initiatives' or 'energising' their counterparts in other agencies. They talked about the importance of maintaining 'working links' to handle redistributive issues. And one interviewee talked about blurring or 'fudging' jurisdictions – allowing responsibilities to be sufficiently vague – that individuals were not strongly motivated simply to redistribute risks away from their territory. Sometimes interviewees described cases where individuals trying to deal with redistributions exceeded their formal powers. In one case, for example, a regulatory inspector had to act beyond his powers to determine the redistributive effects of a land use planning application. This is not to say that the informal domain was the only arena for dealing with redistributions. Informants described formal agreements between regulatory agencies in the UK, for instance, to act jointly in the nuclear industry. These were specifically developed to replace informal arrangements that had manifestly failed. Yet the inclination towards informality was otherwise a strong theme in our interviews.

Interviewees also tended to argue that they were not generally stopped from dealing with redistributional issues, stressing that an aggregating risk assessment was only ever one of several inputs to their decision processes. Their preference for avoiding formal analysis of redistribution was anyway caught up in their scepticism of formal quantitative risk assessment, particularly the feasibility of finding sufficient data. Two interviewees separately described how, in connection with specific cases in land use planning and tunnelling processes, an attempt had been made to undertake quantitative redistributive analyses. The redistributive nature of the problems meant that the assessment had to deal with a whole chain of countervailing risks and a large set of accumulating uncertainties. This made the assessments so demanding in terms of data and modelling that the process in both cases was essentially inconclusive. Redistributions needed finer-grained data, in general, since average exposures and effects had to be replaced by distributional information. An example was the possibility that asthma sufferers would suffer more from proximity to a chemical installation than non-sufferers. Any kind of analysis of how risk was redistributed by changes in the use of the installation would need data on this differential risk rather than population averages.

Scepticism about dealing more formally and analytically with redistributions was also based on the idea that redistributive issues that turned out to be significant would naturally reveal themselves. Formal procedures and methods of analysing redistribution were seen as not only consuming resources but also raising levels of attention where it might not be warranted. The best approach to managing risks in some interviewees' eyes was empirical, stressing the importance of acting on perceived needs and seeing what emerged as redistributive issues. The notion of analysing such issues in advance seemed heavy-handed to them.

Finally, a kind of informality was regarded as being necessary to allow risk managers to take account of actors' motives. An example arose in two interviews in which interviewees talked about sub-standard or defective railroad vehicles. In both interviews, the issue was of how a regulator should react to a train operator who was arguing he should leave such a vehicle in service as otherwise a certain number of people would travel by car, risk would be redistributed, and in the process the overall risk level would rise. In one of the interviews the operator was having to cope with unforeseen events beyond his control; in the other the operator was trying to avoid buying new equipment. Thus, although the redistributional issues looked similar, and the risk assessments produce similar results, the intentions of the main actor were different in the two cases. In the eyes of the interviewees it mattered in the long-run process of managing risk what motivated risk owners in their actions, and they wanted the flexibility to take account of this.

Discussion

Redistribution is ubiquitous

The observations that were made on how redistributions occur indicated that they are very common, if not ubiquitous. They accompany action to intervene in or change a system, but they arise equally when leaving a system alone to adapt or degrade – whether this is because of trade-offs, processes over time, the attempt to maintain standards or by-products of various risk management practices. Given our understanding of the interconnectedness of systems (e.g. Beck 1992) and the fact we live in a 'multi-risk' environment (Wiener 1997), this is hardly surprising. It is not simply that we always seem to experience 'risk transfer' when we intervene in such systems, but that we always face normal developmental processes within such systems even when we do not intervene, and that our perspectives on such systems always evolve with our experience of them even when they do not physically change. All these forces contribute to shifts in the way risk, as perceived or analysed, is loaded onto the categories we find significant at any time. These shifts have a qualitative significance that should lead us to question our capacity to cope with them at one systemic level or another.

Redistribution is managed but does not strongly exist as a concept

A second main inference has been that redistribution as a general concept has little significance as an organising principle. It is mostly not formalised or institutionalised. Specific redistributional issues occur and enter decision processes, but there is no evidence in policy or practice of the idea, developed in the Introduction, of redistributional analysis having an equivalent status to an aggregating risk analysis. This did not mean that it was generally ignored. It was attended to as a specific, local phenomenon,

and it occurred as an input to processes of risk assessment. But analysis of redistribution was not an output of risk assessments, and as a managerial problem it was often managed in the informal domain.

One reason for resisting formalisation was informational: the magnification of data requirements associated with distributional rather than aggregating risk assessment. This is consistent with Gray and Hammitt's (2000) point that data gaps impede the effective analysis of risk-risk tradeoffs. Our informants were keen to tell us of cases where far-sighted individuals had seen the potential for redistributions and had been keen to undertake more holistic analyses than were normal. But such analyses had been confounded by uncertainties and the absence of data. A second reason for avoiding the formalisation of risk redistribution was attentional. We are used to the idea that, through social amplification processes (Kasperson et al. 1988), people make an issue out of a mere suspicion. And we are used to the idea of a 'reassurance-arousal' paradox in risk communication (Otway and Wynne 1989): more information can provide more capability to deal with a risk and its ramifications, but it can also produce more anxiety. This naturally leads to a strategy of avoiding redistributional issues unless others raise them first.

A final reason for resisting formalisation was organisational. When people talked about redistributions they often talked about organisational boundaries. Redistributions of particular significance were often those that crossed important categories – for instance categories of harm like individual safety, damage to the natural environment, economic loss and so on. These same categories, however, are the basis for institutional design. The environmental regulator is a quite separate organisation from the safety regulator; the aviation regulator is quite different from the offshore regulator and so on. Thus significant redistributions naturally cross organisational boundaries, and where they cross such boundaries it naturally looks harder to resolve them. It has been suggested in the past that the specialisation of regulatory jurisdictions gives us reason to believe that risk regulation generates excessive countervailing risks (Wiener 1998). Our interviewees, perhaps naturally, did not admit to this – but they did often talk about resorting to informal practices rather than institutional re-design as the way to tackle redistributive problems. This was not exclusively the case, but there was a sense that most kinds of formality stabilised or rigidified a particular way of dealing with potential redistributions, and that it was beneficial to have room for manoeuvre.

Conclusion

The intended contribution of this article has been to argue for a general concept of risk redistribution that goes beyond redistributions of risk over social groups to redistributions of risk over any relevant categorisation. This includes redistributions across failure modes, redistributions across the high probability/low consequence–low probability/high consequence boundary, redistributions across different kinds of harm and so on. What all such changes seem to have in common is the way they threaten coping capacities that have evolved to fit the way risk is historically distributed over categories of significance to society. Redistributions matter because risk management is adapted to specific risk distributions, and this seems to be true at all levels of analysis, from the detailed and technical to the broad and social.

The study attempted to analyse the redistributions that regulators and consultants identify in their work, and the way in which they deal with them. It found that the

elements of the risk assessment process provided some information about risk distributions, but generally got nowhere near showing how the risks experienced by particular groups, the risks of particular kinds of outcome, or the risks of particular kinds of failure mode, changed with a new technology. Nonetheless specific redistributive issues were commonly encountered by the informants, and these were typically dealt with by informal, flexible, empirical, improvised and often collaborative processes. This preserved flexibility, avoided provoking redistributive issues where they otherwise would not arise and allowed risk managers to take account of what they thought were the intentions of actors making redistributive arguments. Risk redistribution does not emerge as a general organising principle among risk managers, but this does not mean to say they have a general insensitivity to redistribution.

In this sense our findings are optimistic about the capability of regulators, and contrast with more pessimistic views of the narrow approach that regulatory agencies sometimes seem to take as a result of the institutional pressures they face (Wiener 1998). Our informants indicated that they were motivated, sometimes quite strongly, to take risks seriously and manage them in their totality, not simply redistribute them into other people's jurisdictions. But to do this they tended not to look for formal or institutional resources.

As a qualitative study, this work does not provide an objective analysis of the redistributions that occur either in particular cases or in a society as a whole. It does not reveal, for instance, whether certain social groups are systematically favoured or prejudiced by the risk redistributions that accompany the introduction of new technologies. It has been more concerned with the way in which redistribution is understood and managed. The study is also grounded in the context of industries like the railroads and offshore hydrocarbons. It seems likely that industries in which there is a greater public interest, more controversial science or more fundamental problems of trust could produce a quite different picture of how regulatory staff deal with redistributions. There are also some basic limitations in the methodology and sampling that mean our conclusions must be seen as provisional and in need of broader confirmation. We have also made no attempt to systematically distinguish the explanations of different groups, like regulators and consultants, nor trace their explanations to their roles or circumstances. The research questions we posed are quite limited in this respect. Nonetheless, the study provides an account of how certain risk managers deal with an idea that seems fundamental to how we cope over multiple levels with the technologies we adopt.

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References

Alcock, R.E., and J.S. Busby. 2006. Risk migration and scientific advance: The case of flame retardant compounds. *Risk Analysis* 26: 369–82.

Bainbridge, L. 1988. Ironies of automation. *Automatica* 19: 775–9.

Beck, U. 1992. *Risk society: Towards a new modernity.* London: Sage.

Bennett, S.A. 2002. Lock and load? Explaining different policies for delivering safety and security in the air. *International Journal of Mass Emergencies and Disasters* 20: 141–69.
Berg, B.L. 1989. *Qualitative research methods.* Boston, MA: Allyn & Bacon.
Bryman, A., and R.G. Burgess, eds. 1994. *Analyzing qualitative data.* London: Routledge.
Cross, F.B. 1998. Facts and values in risk assessment. *Reliability Engineering and System Safety* 59: 27–40.
Douglas, M. 1986. *Risk acceptability according to the social sciences.* London: Routledge.
Finkel, A.M. 2008. Perceiving others' perceptions of risk: Still a task for Sisyphus. *Annals of the New York Academy of Science* 1125: 121–37.
Glaser, B.G., and A.L. Strauss. 1967. *The discovery of grounded theory.* Vanick, NY: Aldine.
Graham, J.D., and J.B. Weiner. 1995. *Risk vs. risk: Tradeoffs in protecting health and the environment.* Cambridge, MA: Harvard University Press.
Gray, G.M., and J.K. Hammitt. 2000. Risk/risk tradeoffs in pesticide regulation: An exploratory analysis of the public health effects of a ban on organophosphate and carbamate pesticides. *Risk Analysis* 20: 665–80.
Gummesson, E. 2000. *Qualitative methods in management research.* 2nd ed. Thousand Oaks, CA: Sage.
Halfacre, A.C., A.R. Matheny, and W.A. Rosenbaum. 2000. Regulating contested local hazards: Is constructive dialogue possible among participants in community risk management? *Policy Studies Journal* 28: 648–67.
Hilgartner, S. 1992. The social construction of risk objects: Or, how to pry open networks of risk. In *Organizations, uncertainties, and risk*, ed. J.F. Short and L. Clarke, 39–53. Boulder, CO: Westview Press.
Hood, C., H. Rothstein, and R. Baldwin. 2001. *The government of risk: Understanding risk regulation regimes.* Oxford: Oxford University Press.
HSE. 1992. *The tolerability of risk from nuclear power stations.* London: HMSO.
HSE. 2001. *Reducing risks, protecting people.* Norwich: HMSO.
HSE. 2006. Technical assessment guide: NSD guidance on the demonstration of ALARP. http://www.hse.gov.uk/foi/internalops/nsd/tech_asst_guides/tast005.pdf (accessed November 27, 2007).
Jasanoff, S. 1988. Judicial gatekeeping in the management of hazardous technologies. *Journal of Management Studies* 25: 353–69.
Jasanoff, S. 1993. Bridging the two cultures of risk analysis. *Risk Analysis* 13: 123–9.
Kasperson, R.E., O. Renn, P. Slovic, H.S. Brown, J. Emel, R. Goble, J.X. Kasperson, and S. Ratick. 1988. The social amplification of risk: A conceptual framework. *Risk Analysis* 8: 177–87.
Leiss, W., and C. Chociolko. 1994. *Risk and responsibility.* Montreal: McGill-Queen's University Press.
Luhmann, N. 1993. *Risk: A sociological theory.* Berlin: Walter de Gruyter.
Lutzhoft, M.H., and S.W.A. Dekker. 2002. On your watch: Automation on the bridge. *Journal of Navigation* 55: 83–96.
Mason, J. 1996. *Qualitative researching.* London: Sage.
Miles, M.B., and A.M. Huberman. 1984. *Qualitative data analysis.* Beverly Hills, CA: Sage.
Otway, H., and B. Wynne. 1989. Risk communication: Paradigm and paradox (guest editorial). *Risk Analysis* 9: 141–5.
Perrow, C. 1999. Organizing to reduce the vulnerabilities of complexity. *Journal of Contingencies and Crisis Management* 7: 150–5.
Renn, O. 1992. Concepts of risk: A classification. In *Social theories of risk*, ed. S. Krimsky and D. Golding, 53–79. Westport, CN: Praeger.
Roberts, K.H. 1990. Some characteristics of one type of high reliability organization. *Organization Science* 1: 160–76.
Schatzman, L., and A.L. Strauss. 1973. *Field research.* Englewood Cliffs, NJ: Prentice-Hall.
Schwarz, M., and M. Thompson. 1990. *Divided we stand: Redefining politics, technology and social choice.* Philadelphia: University of Pennsylvania Press.
Slovic, P. 1987. Perception of risk. *Science* 236: 280–5.
Slovic, P. 1998. The risk game. *Reliability Engineering and System Safety* 59: 73–7.
Strauss, A., and J. Corbin. 1990. *Basics of qualitative research.* Newbury Park, CA: Sage.

Thompson, P.B., and W. Dean. 1996. Competing conceptions of risk. *Risk: Health, Safety & Environment* 7: 361–84.
Viscusi, W.K. 1984. The lulling effect: The impact of child-resistant packaging on aspirin and analgesic ingestions. *American Economic Review* 74: 324–7.
Viscusi, W.K. 1996. Economic foundations of the current regulatory reform efforts. *Journal of Economic Perspectives* 10: 119–34.
Walker, R., ed. 1985. *Applied qualitative research.* Aldershot: Gower.
Wiener, J.B. 1997. Risk in the republic. *Duke Environmental Law and Policy Forum* 8, no. 1: 1–21.
Wiener, J.B. 1998. Managing the iatrogenic risks of risk management. *Risk: Health, Safety & Environment* 9: 39–82.
Wilde, G.J.S. 1982. The theory of risk homeostasis: Implications for safety and health. *Risk Analysis* 2: 209–25.
Williams, R.A. 1998. A general theory of risk redistribution. Paper presented at the annual meeting for the Society for Risk Analysis, December 6–9, in Phoenix, AZ.