



Evidence or Otherwise of Scale Aversion: *Public Reactions to Major Disasters*

Technical Note 03

June 2009

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Health & Safety Executive

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June 2009

Reference 0091699-TN03 Rev 4

REVISION RECORD

Revision	Date	Comments
00	08.12.08	Draft for internal review
01	09.12.08	Issued to HSE
02	22.01.09	Updated for HSE comments
03	10.02.09	Updated for HSE comments
04	26.06.09	Updated with additional research

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Reviewed by Tim Geyer

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For and on behalf of
Environmental Resources Management Ltd

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Date: 26th June 2009

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1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

This report sets out the findings of work undertaken by Environmental Resources Management (ERM) that aims to support the Health and Safety Executive (HSE) in the wider consideration of the measurement and 'control' of societal risk.

This report describes ERM's recent research activities, the scope of which has been specifically focussed on:

- establishing whether there is evidence of scale aversion in public reaction to major accidents involving the onshore major hazard industries and if so,
- to examine whether this can be measured in mathematical terms to allow it to be taken in to account in the assessment of societal risk; or,
- whether it is more useful to address scale aversion by other means, if at all.

1.2 BACKGROUND

ERM was asked by the HSE to review examples of public reactions to major accident disasters in order to establish evidence or otherwise of scale aversion. This forms part of an extensive programme of research undertaken by the HSE into societal risk in the context of land use planning and risk reduction decisions.

The following activities have been undertaken by ERM to examine evidence of scale aversion:

- A review of existing research in relation to risk aversion, scale aversion and risk perception;
- A review of case studies of major accidents and public reaction; and,
- A review of social impact assessments undertaken by ERM where risk perception was an issue.

1.3 DEFINITION OF TERMS

Risk, risk perception, risk aversion and other associated topics have been the focus of research and debate for approximately 40 years. They are subject to wide ranging views, interchangeable definitions and conflicting academic perspectives. The terms used do not have, by any means 'homogeneous meaning' (Enander & Lajksjo, 2003) throughout literature and research.

The following are the terms as they are understood for the purposes of this report:

- *Risk Aversion* - Is a hugely wide ranging concept used in economics, finance, and psychology and relates to the behaviour and expectations of people under *uncertainty*. Risk aversion as described in economic terms is the reluctance of a person to accept a bargain with an uncertain payoff rather than another bargain with more certain, but possibly lower, expected payoff. In a 'Note on Risk Aversion Definitions 2008' the HSE define risk aversion as the response of *uncertainty adverse* individuals. The principal concept in risk aversion is uncertainty.
- *Scale Aversion* - As a specific term appears in one document, developed by the HSE, where it is defined as "*the tendency to want greater protection where consequences are high*"... For example, a scale averse person would prefer 100 deaths as the result of more frequent incidents in a ten year period than a single event with 100 deaths in the same period. The term itself is important as it focuses on the concept and notion that people are averse to the scale and extent of consequence rather than a more general sense of uncertainty. We use this term throughout this report.
- *Risk Perception* - Is the subjective judgment that people make about the characteristics and severity of a risk.

1.4

SUMMARY OF KEY FINDINGS

- There is some *research* based evidence for scale aversion and some against. The greater weight of research demonstrates that, even where it is evident, scale aversion is not consistent and is dependent on numerous factors many of which are themselves subject to change and are subjective. Therefore, although scale aversion may exist in some situations, it is not a consistent phenomenon.
- As there is little by way of consistent, 'tidy', predictable evidence for scale aversion both in research and public reaction to major accidents, it is neither practical nor sensible to attempt to measure it in mathematical terms.
- There is evidence that factors other than scale of consequence contribute to risk perception and aversion. A revised decision making framework that seeks to address societal concerns by focussing solely on scale aversion may misrepresent the real issues affecting the concerns of different communities and groups subject to any decision making process.

- There is evidence that the means by which risk is communicated by experts to 'lay people' affects the extent to which people feel concern and can influence in a negative sense people's perception of risk associated with a specific development. Consideration of this should be made in any policy aiming at addressing societal concern.
- Assessing public reactions to major accidents as a means to establish evidence of scale aversion is challenging as the measure of public reaction for any such assessment is very dependent on the media coverage, which in itself is 'an amplifier' of people's reactions (Kasperson, 1992).
- Social impact assessments have shown that the perception of risk and loss in society/communities/groups and individuals is not limited to a remote sense of 'fatality'. There is a 'wider sense of loss' which incorporates a much broader notion of loss/consequence than that considered by 'traditional' measures of risk. For example people worry about what might happen to their homes. There is a lack of 'compartmentalism' in public perception of risk (Irwin, Simmons, Wynne & Walker 1998); people do not tend to limit their perception of risk to accident risk but frequently also reason in relation to other effects such as the impact of a plant on a local area and pollution.
- Although this has not been examined in detail, there is a case for making a distinction between pre-accident aversion and post-accident reaction. The former relates to the general concern of societal groups who have not encountered (or observed via media) a specific accident. This aversion can be affected by a wide range of local elements such as a community's history with a site, whether a site smells or looks unattractive and beliefs about specific organisations. The latter relates to social reaction to a specific accident and the concerns that this arouses. This again is subject to a range of influencing factors such as media amplification. Scale may be a contributing factor to both pre accident aversion and post accident reaction. However it is rarely the dominant factor.

The volume of research in this area is very large. This review looked at a broad range of material that included, but is not limited to, existing research undertaken by risk experts (a number of which have been written by or for the HSE). The aim here is not to add to the mountain of academic discussion about the use of mathematics in risk modelling, but to identify research evidence of scale aversion with the aim of establishing whether it can readily be measured as part of a decision making process in a wider consideration of societal risk.

Annex A provides a table summarising the research reviewed. This section provides a more detailed description of the range of literature relating to the issue.

2.1

A COMPLEX ISSUE

Ball and Floyd (1997) produced the report *Societal Risk*, for the HSE, in which the authors describe the evolution of societal risk criteria. They note the inception of the idea, with the 1967 Farmer Curve, and its connection to nuclear industry calculations about frequency and consequence (Ball and Floyd, 1997). They observe that the 1974 Flixborough incident impacted decision-making policy. They go on to detail the development of QRA in the 1970s and the eventual use of FN curves. The authors note that following the Sizewell B Inquiry, the HSE commissioned research into the tolerability of risk (1988). This focussed on individual risk rather than developing work on societal risk.

Ball and Floyd explore the meaning of *societal risk*, ranging from definitions centring on the frequency of an event combined with the number of people suffering consequences, to the more inclusive definitions which take account of other dimensions of harm, or socio-political responses following major accidents. They consider societal risk as comprising of four elements:

- *simple* societal risk involving human safety only where consequences are measured by ‘fatalities’;
- *diverse* societal risk that considers other dimensions of harm;
- *societal concerns* (which are strategically and politically relevant); and,
- *collective risks* that are diffuse throughout society and include topics such as air pollution.

They note that the ‘broader concerns’ associated with societal risk must *supplement* FN curves, stating that decision making based on FN curves alone would be “meaningless” (Ball and Floyd, 1997 p.6). This finding echoes to a certain degree the suggestion made by the Royal Society Study Group’s Risk Assessment publication that “...at the more strategic levels, risk management

is ...an essentially political process, informed by technical estimates" (RSSG 1983 p 16).

In exploring 'Multiple Fatality Aversion' Ball and Floyd assert that there are numerous factors that influence the perception of hazards by the public. They discuss the use of utility functions describing the societal cost of 'N' lives lost in a simple accident, where the cost is some function of N^n - the exponent n is '1' for a risk neutral position, >1 for a risk averse (or scale averse) position and <1 for a risk seeking position. They conclude that risk neutrality should be adopted in public policy making, and that additional issues and consequences would be better dealt with as 'supplementary factors' in decision making (Ball and Floyd, 1997 p.25). Furthermore, they argue that public perception is difficult to elicit and to incorporate into decision making.

Enander and Lajksjo (2003) writing in *Risk Aversion: the term and the phenomena* for the Swedish government describe risk aversion as *the importance afforded to risk increased disproportionately to the scale of the possible outcome – an incident involving 100 victims is worse than 100 events involving each involving one victim* (p. 1). This definition is compatible with the 'scale aversion' definition described above.

In another paper for the HSE, *Taking account of societal concerns about risk: Framing the Problem*, Adams & Thompson (2002) describe the initiative to include public perception in risk management decision making as constituting a 'paradigmatic shift' (Adams & Thompson, 2002 p.12). The paper notes the distance that has long separated the objectivist (mathematically-based) tradition of risk management from the constructivist literature that has often been critical of this approach. The authors expressed the view that 'societal concerns' can be fruitfully explored via constructivist methodologies and cannot be "bolted on" to objectivist practises (Adams & Thompson, 2002 p.12).

The distance between 'expert' mathematically based, traditionalist approaches to risk and public perception of risk is a recurring theme. Sandman et al (1993) found that people are not concerned or as affected by the technical aspects of risk as they are by the means by which risk is communicated. The authors undertook two studies: the first presented subjects with two fictitious news items with different framing of outrage and expert agreement. They found that the way an issue is reported impacts on the perception of risk. In the second study it was found that conflict amongst experts and a low level of trust in those experts increases the perception of being at risk (this is expanded in more detail in later sections.).

In a report for the Australian Rural Industries Research and Development Corporation, Botterill et al (2004) expand this theme further. They note that anxiety about science is a factor affecting risk perception, on the basis that science has been wrong before. They state that where the expert view on risk is concerned with probability, those of lay people take a binary view, *either something happens or it doesn't*. They describe a fundamental mismatch in the "rival rationalities" of lay people and experts (Magolis, 1996, in Botterill et al

2004). They describe how trust in science in general has decreased over time where experts have been seen as changing their minds or disagreeing. To some extent they support the notion of consequence as a factor that causes concern by describing how people worry about negative consequences irrespective of the low probability of an incident actually happening – the ‘what if’ scenario.

They also state that risk perception is about personal feeling and memory (previous experience) and “*other factors*” and does not appear to correlate with measurable probabilities of risk (Botterill et al 2004).

Sjoberg too focuses on the gap between expert and lay persons’ perceptions of risk. He cites that, expert assurances about safety notwithstanding, no country had at the time of his writing found a voluntary local community willing to host a facility such as a high level nuclear waste repository (Sjoberg, 1999 p. 1). He shows that experts’ and lay persons’ perceptions often disagree, and casts doubt upon the view that this is due to ignorance on the part of the public. He shows that mistrust (of experts) is ‘consistently, and moderately strongly, correlated with perceived risk’. He asks whether assessments of risk are based on experience of disaster. He notes first that “...*people are quite concerned about radiation even before there is an accident*”. Radiation is associated with cancer, it cannot be sensed and avoided and it is even associated with the horrible images of nuclear war’ (Sjoberg, 1999 p. 6). He notes that radiation is seen in a positive light in the context of medical use of ionising radiation (Sjoberg, 1996). Here, people are afraid, not because of the potential impact (scale) of an accident, but because of associations with negative imagery and lack of knowledge.

Risk communication is examined in a range of literature as a factor that consistently underlies the issues associated with the *rival rationalities* of expert vs. lay person perception and understanding of risk. Botteril (2004) and Slovic (1999) among others describe traditional models of risk communication that ‘*tend to define the public as an essentially naïve audience and recommend a ... process where increasing amounts of technical and scientific information are disseminated to the public to counteract ‘irrational’ opinions and to build support for the various policies in the face of opposition*’. They suggest that this ‘traditional’ approach does not address the wider ‘non technical’ issues that actually affect risk perception within non expert groups. Examining the British government’s reaction to the BSE crisis, Randall (2002) found that in failing to be open about what was known and not known damaged commercial interests and lead to ‘*virtually unmanageable levels of public mistrust*’ (Botteril, 2004). Slovic (1999) believes that using science to communicate with untrusting audiences feeds public concern.

Trust in experts is described by Starr (1984) as the extent to which the public have faith in authorities’ ability to cope with the risk rather than remove it completely. Section 4 below examines social impact assessments undertaken by ERM and finds that the means by which experts communicate risk is in itself a factor that affects trust which itself affects risk perception and aversion

in the public. People expect 'authorities' (regardless of who they might be or their specific role in delivering policy) to demonstrate their competency in managing risk and in dealing with the result of an incident as opposed to worrying about the frequency and consequence calculations. To quote Botteril and Mazur (2004) '*people are happy for tigers to remain on display in zoos as they trust zoo managers to keep the tigers securely caged*' (p.11).

Jones-Lee and Loomer (1995) published results of their willingness – to- pay travel safety study into scale and context effects in valuing safety improvements in transport. Research was conducted (in 1993) and rejects various arguments for scale aversion (Jones-Lee and Loomer, 1995 p185-6). They suggest that aversion to certain types of risk is due to characteristics of the context, which are not as simple as their being large scale but involve other factors such as control (p187).

AEA Technology presented the HSE with *A Model Framework for Societal Concerns* (2002) in which the authors attempt to model the interactions of different factors in order to calculate a value for estimated overall societal concern associated with particular issues. The usability and relevance of the logic tree structure that they present is not discussed here; however they provide a set of factors that have been found to influence societal concern. They highlight that an "*overriding distinction [exists]... between those issues where the risk could be managed [controlled] by the individuals who were at risk and those situations where the management of the risk was by someone else*" (p16).

Weber et al 2002 found people "*do not appear to be consistently risk seeking or risk averse across different domains and situations even when using the same assessment method*" (Weber et al 2002, p 264).

Covey et al. (2008) describe research performed on behalf of the Rail Safety and Standards Board (RSSB) in considering an appropriate level for the Value of Preventing a Statistical Fatality (VPSF) for rail accidents. Respondents to a nationally representative survey were presented with a series of 'matching questions' designed to elicit relative preferences. These questions sought to establish the number of rail fatalities of a given type that would need to be prevented by a safety improvement in order for the respondent to regard that safety improvement as being as 'equally as socially desirable' as the prevention of a given number of baseline case fatalities. It was found that, in the matching questions, no more than half the respondents regarded the prevention of a fatality in a multiple-fatality rail accident as taking priority over the prevention of a baseline case fatality in a single-fatality rail accident.

Research seems to demonstrate that rather than a straightforward aversion based on the scale/consequence of an incident as understood in traditional risk terms, that a range of other subjective phenomena are at play. People access most of their information from the media (Whalberg & Sjoberg, 2000 p31). Media reporting is in many respects unrepresentative of actual incident severity. Social learning theory suggests that the perception of risk is

distorted by media sensationalism whereby people learn from second hand experience rather than more rare first hand experience (Bandura, 1977).

Tyler and Cook (1984) in their *personal impact hypothesis* postulated that '*hazard information will have different impacts on perceived societal and personal risk level*'. This means that a person can be influenced by, for example, media images of catastrophes, to believe the risk to society to be increasing; however this judgement will not effect personal risk calculations. Sjoberg 1999, however, stated that personal and societal risk judgements often correlate closely. Assumptions based on personal experience are difficult to dislodge even in the face of contrary facts. Sjoberg found that even without facts individuals hold opinions about risk and that the presentation of the facts may not necessarily change their view.

Plapp and Werner (2006) note that 'lay people' undertake risk assessment unconsciously as a *value judgement* that is both intuitive and influenced by cultural factors. They define risk as a 'multidimensional concept' that comprises an assessment that calls upon experience, information and qualitative risk qualities (Renn summarised in Plapp and Werner, 2006)

2.2

RESEARCH EVIDENCE IN SUPPORT OF SCALE AVERSION

Research to date has not demonstrated a straightforward evidence base for scale aversion. However there is some evidence that it does exist in some contexts.

Han Bleichrodt & Jose Luis Pinto (2002) undertook research into loss aversion to determine whether it follows specific patterns with the aim of modelling any effects ⁽¹⁾. Their research studies loss aversion in the context of medical decision making. They find "*significant evidence for loss aversion*" in participants' responses to medical decision making contexts. However they also find that the effects of loss aversion are not constant, but vary over trade-offs and that most participants do not behave consistently. They state "*The rejection of a constant loss aversion ... is discouraging for attempts to model loss aversion...*" In this context loss aversion refers to the avoidance of any (perceived or actual) 'loss' as a result of poor decision making in the medical context rather than focussing on the scale of particular loss.

In their work to develop a Model Framework for Societal Concerns (2002) AEA list a set of 24 specific parameters drawn from their review of work into societal concern. Included in this set of parameters is "*Infrequent but high consequence/catastrophic events vs. many small events*" (page 18).

Enander and Lajksjo (2003) in a comprehensive report examining the term risk aversion and the phenomena associated with it explore different methods in the qualitative determination of the existence of risk aversion. The authors

(1) Journal of Mathematical Psychology 2002 – Loss Aversion and Scale compatibility

identify aspects of major accidents that may contribute to a sense of aversion; this includes 'dreadfulness' of a potential cause of death, or the degree of vulnerability of the specific groups suffering consequences (i.e. children). The authors give various reasons for their consideration of risk aversion, as follows:

- Major hazards often have other negative effects on society besides the quantified damage indicators (indirect damage or consequential damage).
- Depending on the impact of the incident, the population intuitively assesses 'damage' differently. This is reinforced by intensive reporting of major hazards by the media.
- Major hazards often have a signalling effect on society. As a result, the confidence and trust that society placed in the activity which originally led to the incident may be undermined. The same is also true of the companies / authorities responsible for the given activity.
- Experience shows that systems recover more quickly from many minor incidents than from fewer major hazards (protection against existential threats).
- Compensation for uncertainties in relation to the determination of the frequency and impact of rare major hazards.

Slovic et al (2000) studied the various factors that influence society's perception of risk. They found that people perceive greater risk from hazards characterised by high ratings on a number of subjective dimensions including the possibility of many immediate fatalities. They state that there is a focus on consequence rather than likelihood which supports the notion of scale aversion to some extent. The work also identifies a number of other subjective factors that combine to affect risk perception. These include a sense of control for the risk or hazard; fear associated with a hazard, equity (i.e. whether those at risk gain any additional benefit); knowledge and understanding of the hazards and risks of those at risk and the novelty of the technology or hazard.

In a study of the safety of a nuclear power plant from a reliability theory perspective, Natvig & Gasemyr (1996) also consider 'risk and risk aversion' as concepts in insurance calculations. They find that in insurance decision making, risk aversion is the product of an underlying general disposition based on 'underlying latent variables'. They suggest that uncertainty is a latent variable affecting insurance decision making. Where uncertainty about nuclear production combined with the possibility (perceived or actual) of catastrophic nuclear accidents results in risk averse insurance decisions. They conclude based on their work that in this context "*It is not irrational to be risk averse when confronted with great uncertainties*" (Natvig & Gasemyr, 1996).

Slovic et al (1979) treat risk as *subjective perception* rather than fact based. They ask whether people assess the risks they face in terms of the number of people it could kill or whether they take more qualitative features of risk into account. They found that people ranked nuclear power as having the lowest fatality estimates, yet the highest perceived risk for two of the groups

involved in the study. They found that people's opinions are stubborn in the face of new evidence. However they also found that for lay people the concept of risk involves qualitative aspects such as dread and the likelihood of an incident being fatal and that risk perceptions were affected by catastrophic potential.

An important piece of research was undertaken by Irwin, Simmons, Wynne and Walker (1998) for the HSE that sets out to examine the 'Public Perception of Risks associated with Major Accident Hazards'. It demonstrates the range of variables that affect people's perception of risk but presents some evidence for scale as one factor in people's consideration of societal risk. The overall aim was to support the HSE and other Government departments involved in developing and operating controls over major accident hazards to achieve a better understanding of public perceptions of the risks associated with major accident hazard sites. They undertook a series of focus group discussions with local residents living within the consultation zone around 7 major accident sites in the UK.

Overall they found that context (i.e. the specific nature of a major accident hazard site and its local community) is one of the key components in the formation of risk perception.

They found that although public responses to risk are often cited as being 'irrational', that people reasoned about risk in quite complex ways, but that these ways differed than those adopted by risk experts (Irwin et al 1998 – viii). They found people, in arguments and discussions about risk in a general sense, tended to focus on the *consequences* of a major accident rather than the probability of it happening.

The research presented focus groups with details of two hypothetical planning decision- making scenarios. The first scenario asked participants to make a decision about where to construct new houses on a number of sites near to a (fictional) existing hazardous installation. There were four sites in total:

- Sites A&B that were smaller and more likely to be affected by the impact of both small and large scale releases as they were located close to the major hazard site and in a location which receives the predominant wind direction
- Sites C&D that were larger sites but that would only be affected by large scale releases because they were further away from the major hazard site and were only in the direction of the wind 20% of the time.

Participants were given three options:

1. to build on sites (sites C & D)
2. not to allow building on any site
3. to allow building on all four sites.

Option 1 was the most favoured across all of the groups, with approximately half of the participants choosing this option. Irwin et al report that the primary argument in support of this option was one of compromise – where ‘it was reasonable to balance the low probability of a large accident affecting sites C & D against the need for housing in the area’ – participants reasoned it was not reasonable to build on sites A&B as they would be ‘more likely’ to be affected than those living in C & D. (Irwin et al 1998 p90-92).

This would suggest that it is probability rather than scale of event that affected participants’ responses.

In the second hypothetical planning scenario, participants were presented with a map showing two installations, neither of which currently holds hazardous chemicals that could give rise to an accident with off-site effects. However, participants were told that the sites are owned by companies that have decided to embark on a joint venture involving the construction of a plant extension that would result in the storage and use of chemicals that, if accidentally released, could have a significant impact beyond the site boundary. Participants were asked to make a choice about which of the two sites is the most suitable for this new extension:

- Site A is located in a sparsely populated area near to a scattering of houses that would be affected by both small and large scale accident events (with small scale events described as ‘more likely’ and large scale events described as ‘very unlikely’). However, a large scale accident would not result in a significantly greater number of casualties as the gas cloud could not reach a major urban area indicated on the map.
- Site B has no housing in the immediate vicinity so that a small scale incident could lead to no off site casualties; however a large scale incident would reach the major urban area leading to a far greater impact in terms of casualties than a large scale incident would at Site A.

This scenario was intended to examine the reasoning people use in making choices between available options with ‘a focus on the significant of societal risk considerations’ (Irwin et al 1998 pg 95).

Overall Site A was given greatest support with half of all participants preferring it. The principal justification for this was the significantly more people who would be affected by a large scale accident at Site B despite its low probability. This differs to responses to scenario 1 where probability rather than scale of impact was identified as a primary factor behind people’s decisions. This finding suggests that scale is a factor in people’s choices relating to societal risk – where participants attach ‘considerable significance to the numbers of people affected by an accident event’ (Irwin et al p112).

However the research provides evidence for a range of other factors affecting risk perception such as familiarity, choice and equity/benefits. The authors, in conclusion, are careful point out that ‘it is not only characteristics attributed to the risk that are relevant but that characteristics of the context of the risk are

also important and that these vary considerably between different sites and localities and communities at risk' (Irwin et al 1998 p 115).

They point out too that were there is a widespread belief in the groups that major hazard sites could have catastrophic consequences, that this did not necessarily lead to a heightened level of concern. Discussions between participants about large scale major accidents involved both anxiety and fatalistic arguments that recognised the potential for a 'big bang' but also that such an event was very unlikely to happen.

In summary, this section sought to present evidence, found in literature and research, for the existence of scale aversion. In some cases the scale of consequence does seem to be a factor in people's perception of risk. However there is little by way of consistent evidence for scale aversion to the extent that it might easily be measured – to quote Enander and Lajksjo it is more true to say "*some people sometimes tend to be avert [sic] to some risks in some contexts*" (p31). There is some support for the view that certain events have a relatively greater psychological and social impact than others although the characteristics of such events are more complex than "*are summed up in the 'ten killed in one event, or one killed at each of ten events' definition*" (Enander, 2004 p25).

2.3

POST DISASTER SCALE AVERSION

Chilton et al (2002) present the findings from two studies assessing any differences in how people evaluate risk before and after an incident. The first was conducted in 1998, the second in 2000 in the aftermath of the rail incident at Ladbroke Grove which killed 31 people. The second study allowed Chilton et al to assess the effect the rail incident had on the evaluation of risk associated with that mode of transport compared with road accidents and fires. It is important to note that the sample used in the second study included a greater number of rail users than that used in the first study. It was found that in the 1998 study 35.4% gave the rail safety programme first or second priority in terms of investment based on risk, this percentage rose to 63.3% in the 2000 study. Chilton et al analysed accompanying qualitative data from the respondents and highlighted the following as factors that appeared to contribute to the upward shift in the relative prioritisation for rail safety:

- Higher perceived personal and household exposure to rail risk (part of which may be attributed to the deliberate over-sampling of regular rail users in the 2000 study);
- Heightened feelings of dread and uneasiness about rail travel;
- The impact of media coverage of the Ladbroke Grove accident as well as the sense of the possibility of large scale loss of life in rail incidents;
- A decrease in confidence in the adequacy of rail safety management; and,
- Moral outrage at a problem that people felt should have been dealt with prior to the incident – a sense that it was preventable.

Analysis of the sampled respondents *'strongly suggests that the rise in rail/road safety valuation ratio was as a result of the Ladbroke Grove incident and the higher rail user representation in the 2000 study'*.

Chilton et al (2002) conclude that people's priorities are sensitive to the combined influence of the number of deaths, psychological characteristics of the hazard and social amplification effects following major accidents. They find that number of deaths does impact people's subjective assessments. However they caveat their findings with the acknowledgement that the risk they presented to subjects was familiar to them and did not represent the 'unknown' quality that is that is representative of high hazard installations.

It is important here to extend this note of caution in using any conclusions drawn from rail incidents and applying them to land use planning policy. There is a fundamental difference between the 'public relationship' with transport services such as rail and the development and operation of high hazard industry. People practise some element of *control* in exposing themselves to the risks associated with using rail services – they chose to travel by train; they have an understanding of what to expect when they get on a train. This notion of control has been found to be a factor that affects risk perception and aversion. The control that people have over their exposure to the risk associated with rail travel is greater than the control they have over their exposure to the risk associated with major hazard installations 'being thrust upon' them by choices made by the 'authorities.'

Sjoberg (1999) provides an insight into post incident risk perception by reporting data collected in a small Russian town Novozbkov in 1992. 185 individuals living in the area were asked to rate 33 dangers and to rate changes in those dangers since the Chernobyl incident. Price increases were rated the top 'danger' with other responses dominated by nuclear and radiation dangers. Common risks such as smoking, traffic and alcohol came last (Sjoberg, 1999 p.7).

3.1 CASE STUDIES

A review of case studies of major accidents and public reaction was undertaken with the aim of assessing whether any evidence for scale aversion might be identified.

It was quickly evident that objective case studies of public reaction to major disasters in the UK in particular are not readily available. Kaperson et al (1988), in their social amplification framework suggest that people's reactions are influenced by the interaction of risk events, psychological, social, cultural institutional processes in society. Hazardous events are communicated via a range of social and individual amplifiers such as media, government and other authorities. They suggest that there is a 'ripple effect' that goes beyond the initial impact of the event.

The limited accounts of reaction that are available are found in the media which, as an 'amplifier' of risk perception is not the best means by which to assess the public reaction to major accidents. Furthermore, local news archives are not readily accessible for review. It is considered that manual searching of local news archives would be time-consuming and would be unlikely to be cost-effective. Annex 2 provides a table showing the case studies available for assessment.

The phenomenon of second hand learning is important in consideration of scale aversion based on public reaction to major accidents. Measures and assessments of aversion in research are predominantly based on work with people who have not experienced an incident first hand. There is an argument, therefore, that there is an important distinction between pre incident concern/aversion and post incident aversion and that policy makers may need to be sensitive to this aspect.

In view of the lack of useful case studies that describe reaction of major accidents, this section looks at the anatomy of pressure groups, assesses reaction of legislators to major accidents and looks in some detail at the reactions to the Buncefield incident and certain rail accidents.

3.2 PRESSURE GROUPS

Pressure groups campaign and lobby for specific causes – it might be a single cause or multiple causes of similar themes.

A web search was carried out and an assessment of pressure groups was undertaken in an attempt, again, to establish whether there is a scale aversion tendency that leads to the creation of, or that drives the agenda of, pressure

groups in the UK. This included a look at pressure groups in the aftermath of incidents. The results of this assessment are summarised below.

3.2.1 *National Pressure Groups (UK)*

A search of UK based national pressure groups found that there are no specific groups that campaign specifically against the development of major hazard installations on safety grounds in the UK. There are however a number of environmental groups that campaign against the development and use of oil and gas, on the basis of the impact oil and gas developments have on both local and global biodiversity and environment; yet they too do not have a specific focus on safety issues.

3.2.2 *Local Pressure Groups (UK)*

Local pressure groups seem to form around daily, persistent annoyances rather than potential catastrophes. For example, see HACAN Clearskies and CrashW4 – groups protesting Heathrow Airport expansions due to noise and to not having been consulted fully. SANE regarding Swansea airport has similar concerns, including a special area of conservation concern. Community campaign groups can become active with regard to specific installations; some organisations are faced with outspoken individuals that form WebPages and campaign against new development. Again the focus of these pressure groups tend to be ruined landscapes/views, although safety risk information too can be used to support an argument against a particular development.

3.2.3 *Pressure Groups Reaction to Major Incidents*

Prior to the Flixborough disaster, local environmental groups such as the Baglan Action Group (BAG) were campaigning about the environmental and health records of local plants. The disaster at Flixborough led the Baglan Action Group, despite being located in Wales and not directly affected by Flixborough to campaign about the potential risk of explosion from such plants. Bennett (1999) uses this to argue that risks are determined partly by objective scientific reality, and partly by social and cultural experience (Bennett, 1999, p. 1). The focus of local newspaper reports about Flixborough was the ominous quality of the smoke fumes emitted during the accident. The author quotes local papers, which were reporting that people had no idea what the fumes were (yellow, dense black) and were consequently very frightened.

BAG had known about the explosive potential at the site, but focused on noise, the effect on property values, dust, odour, light pollution, and residents had complained around these issues. This correlates with the review work undertaken here into social impact assessment undertaken by ERM (see section below). Workers' health issues entered the debate when a local paper reported such issues with workers in America coming into contact with

dangerous substances. Media sources and individuals seem to require a cue to prompt them to focus on the more unlikely but highly significant events.

The local paper, the Echo, reported after the Flixborough event that *experts have said this sort of thing could happen again* (Bennett, 1999 p. 2). This is testament to the sort of 'binary' style thinking about risk discussed above, and does suggest that, although the potential for these events was present before, it has become highlighted by the event, and found less palatable after the disaster. In further support of this sort of reaction, the local Tenants' Association, and local environmental groups arranged meetings with the operator centring then on the management of potentially disastrous risks. Before the risk of explosion, or large scale fire was known (prior to 1974), there was little public pressure from groups, except Friends of the Earth, who were partially concerned with safety.

Furthermore, following Flixborough, and the 1977 Windscale Inquiry (dealing with the building of THORP nuclear waste reprocessing plant), which highlighted the scale of risks involved, pressure and involvement increased, including later attempts to stop THORP from being built, (Lofstedt, 1997, p. 19).

3.2.4

Buncefield

Other than the investigation and media reports there has been little wider research or academic attention given to the social impact of the Buncefield incident. However, the East of England Development Agency funded a social impact assessment. The work was commissioned by a community task force led by Dacorum Borough Council and issued on their website. The aim of the report was to make an independent assessment of the community recovery operations.

The research was carried out over the ten months following the incident and involved focus groups, task force meetings and other council based community projects.

Some of the key findings in so far as they provide an insight into the impact and reaction to the incident 'on the ground' are set out in this section.

Perception

The report states that during the first 48 hours after the explosion police received over three times the usual number of calls and dealt with 142 missing person reports (p.21).

People were primarily worried about air pollution and concerned as to whether there would be further explosions.

In the medium term in the weeks following the incident one in seven people replying to a community survey expressed concern about the future of their jobs and 56% had concerns about the loss of property value.

In the longer term (i.e. at the time the report was issued in January 2007) the report states that *"people were worried about the future of the site where different reports and rumours serve to strengthen the fears of the local community"* (p22).

Interestingly the report states that people have criticised the information provided by the Council, HSE and other organisations for being "too scientific" and for not considering the concerns of the community – such as whether the depot is 'still dangerous' and who was to blame (p22). A common concern was that no one had *asked* people affected by the incident about their needs or concerns (p23).

Although the emergency response was on the whole felt to be good, the researchers noted that there was some debate about whether the government response would have been 'better' if the incident had occurred in a more deprived area or if people had died (p29). This seems to be focused on compensation and the longer term loss of housing for an unfortunate few.

The scale of loss

The report provides little by way of numerical or statistical evidence for the magnitude of the loss experienced. However it is clear that the impact is on a larger scale and more complex than would be usefully 'captured' in traditional risk measurements of consequence. Researchers found that where emergency response fell into place 'fairly quickly' the social impact had lasted much longer than was assumed or catered for by emergency plans (this observation refers primarily to council emergency plans). They state that *'the continuation of impact long after the incident itself is both unexpected and disturbing. Like a stone thrown into a pond, overtime the impact has grown but is becoming increasingly difficult to trace directly back to Buncefield.... in many cases the [Buncefield] incident could be seen as a catalyst for disturbance'*(p29). This is interesting in the context of this report whereby scale of consequence (scale aversion) is the key theme. It is clear that the actual impact and scale of consequence - in terms of the lasting affects, type of harm caused and the type of loss experienced by affected groups is much greater than anticipated and different in nature than the 'loss' and 'consequence' and 'scale' as measured in traditional risk terms.

The consequences and social impact of the Buncefield incident have changed over time with the immediate and short term impacts of the incident differing to those present in the months that followed. They have also identified that different community groups have been affected in different ways.

- Local Residents

The report quotes a local resident as saying - "*it was not necessarily the explosion itself that has caused so much effect and impact on families, it is everything since*" (p13).

A number of privately owned houses suffered structural damage and some people were still living in hotels a year after the incident. Some people have had to move in and out of properties on a number of occasions because structural damage has caused recurring problems. For these few the impact has been considerable in both practical and emotional terms.

People reported that dealing with insurance companies was one of the greatest stressors resulting from the explosion with people still 'battling' with insurers months after the event creating financial challenges.

The report suggests that some local residents have a sense that Buncefield has been 'brushed under the carpet' and that ongoing problems are being forgotten (p14).

- Local Employees

90 businesses in the local area (the Maylands) were 'severely affected' by the incident whether as a result of damage to their premises or other business assets and/or general production disruption as a result of restricted access.

Employees working with agencies or contractors lost jobs almost immediately. Businesses that continued to operate but suffered costs over a longer term cut jobs in response to these losses. Larger companies were sometimes able to relocate other premises.

The researchers describe a psychological impact relating to the 'fear of losing' employment as having had a significant, yet difficult to measure, impact on local employees. For those who had lost their job, employment agencies reported an incomplete take-up of benefits provided by the welfare system; people were reluctant to be stigmatised by being on benefits, even if they could not live on the amount offered, or they remained loyal to their companies believing that they would get their jobs back. Those sole traders and small businesses affected described the effects of Buncefield as *losing everything we had worked for* (p7).

- Children

Over 200 schools were closed for two days following the incident. Counselling services were set up to support children who were affected. As the explosion took place when it was dark, some children were frightened at night and could not sleep. Older children were affected by 'what if' scenarios. It is not clear from the report what proportion of local children were affected in this way.

Communications

98% of respondents to a community survey stated that they used television to keep up to date with events during and after the explosion (p16). This is interesting when one considers the implication of the amplifying effect of media discussed in earlier sections. The HSE appointed a Community Relations Officer who worked with the community and local businesses. The local council issued posters and newsletters and ran community forums.

3.2.5 Rail Incidents

Assessment of public reaction to major rail accidents including Paddington, Hatfield and Ladbroke Grove demonstrates a sense of outrage at the mismanagement of public funds (i.e. train fares) – *“the average Londoner pays approx £1000 pa to travel like a piece of meat”* and a tendency towards a scale averse reaction in some individuals - *“When are the government going to take heed that our railway system is probably more dangerous than travelling by car”* (BBC News online ‘initial reaction to London’s rail disaster’ 1999)

Public outcry (as represented by the media) tends too to seek an accountable person or body to ‘blame’ for failings that result in disaster.

3.3 LEGISLATION

There is some evidence that suggests that legislators and perhaps institutions are ‘scale averse’. Legislators seem to be moved by large scale disasters more than they are by frequent and small-scale accidents.

The Seveso incident July 1976 lead to the EU Seveso Directive, part of considerable industrial safety reforms and standardisation set in place as a result of the accident. The accident itself did not result in any immediate fatalities. Although a large number of people in local communities were exposed to TCDD (tetrachlorodibenzo-p-dioxin) and studies are ongoing to establish the health affects of the disaster. The Seveso Directive was later replaced by the so-called Seveso II Directive (96/82/EC).

A further example of this might be the 2003 directive 2003/105/EC of the EP amending the Seveso II Directive on control of major-accident hazards involving dangerous substances. This legislation cites several industrial accidents as motivating the extension of the provisions. The disasters included the cyanide spill that polluted the Danube following the accident at Baia Mare, Romania, January 2000; the fireworks accident at Enschede in the Netherlands, May 2000; and the explosion at a fertiliser plant in Toulouse in September 2001.

The explosion of ammonium nitrate, causing 30 fatalities and an estimated 10,000 injuries, occurred on 21 September 2001 at the AZF plant in Toulouse operated by a Total subsidiary. The accident consequently caused very serious destruction, damaging some 27,000 dwellings. Estimates issued by national and local authorities indicate that 10,000 people were injured (physically). A further 14,000 people applied for medical treatment for acute post-traumatic stress in the months following the explosion. The Toulouse disaster prompted nationwide debate, leading to a new law to improve risk management (2003-699). It introduced a significant change to the prevention of technological risks. The second part of the law reflected lessons learned from recent floods and natural disasters (flooding caused by the Somme, Gard and Hérault rivers). The disasters at Enschede and Toulouse reminded Europe that the control-based Seveso II directive (in particular its Safety Management System requirement) was not enough to prevent major accidents turning into disasters.

Ball and Floyd (1997) for the HSE (reviewed above) detail a full chronology of disasters and their impact upon legislation. Some disasters are cited by the HSE themselves as drivers for the legislative changes.

These examples show that it is not necessary for fatalities to be a consequence of an incident for considerable legislative change to occur as a result. However, where legislation has changed as a result of an incident the 'potential' for harm from the incident was considerable. There is, therefore, some indication that investment in terms of legislative development as a result of major accidents is correlated with major accidents and that legislators themselves may have a tendency towards a scale averse reaction. However more research is required to establish clear evidence for such a direct relationship between 'scale aversity' and regulatory reaction to incidents.

4.1**INTRODUCTION**

In support of establishing the case or otherwise for scale aversion, a review of social impact assessments was undertaken. This activity focussed on the work carried out by ERM's Strategic Services (SST) team who support industry in assessing and addressing the impact of their operations on society. Their work includes facilitating resettlement, running community engagement programmes, implementing external stakeholder engagement programmes and assessing the impact of industry on specific communities.

The aim of this activity was to use the wealth of 'field experience' and knowledge of the members of the SST team in order to identify any evidence or pattern in communities' perception of risk and whether there is evidence of scale aversion, in their experience.

Again it should be noted that the typical work that the SST team undertake is with communities who have not experienced an incident. It does not therefore represent public reaction to major accidents, although it does highlight some of the factors that determine risk perception /aversion and that contribute to societal concerns.

This work comprised of a workshop with key SST personnel. The workshop took the form of an unstructured interview. Attendees were asked a range of high level questions relating to their experience of risk perception in communities. In preparation for the workshop they were asked only to consider work undertaken in the UK. It is understood that this review is open to subjectivity however; the field experience of the attendees is valid in so far as they have had 'front-line' exposure to societies' concern.

The following sections present the findings of the social impact assessment review.

Unsurprisingly, the attendees noted that risk perception, aversion and concern are affected by the context and specifics of a number of factors. It by no means falls into an easily predictable pattern. There are, however, some key factors that affect people's risk perceptions and aversion.

4.2**REPUTATION & TRUST**

People's perception and/or trust in an organisation tends to correlate with their sense of risk in relation to the organisation's undertaking rather than the nature of the undertaking itself.

If a company executive is indicted even on an unrelated matter (such as tax evasion) people distrust the organisation as a whole. It is assumed, for example, that they will *'try to get away with anything'*.

Feeling belittled or ignored by experts or industry representatives increases suspicion of industry organisations and experts. This in turn affects trust and perception of risk – *'they have something to hide'*.

SST has found that the more 'open' and trusted a company is, the less the scale of fear within affected communities.

4.3 *AREAS OF CONCERN*

The key focus of people's concern is not necessarily death or the risk of it. People tend to worry about chronic health issues such as air pollution caused by plumes *"anything with a plume is going to kill us eventually"*.

Another key factor is the effect a high hazard installation has on the structure and nature of a community i.e. access to often used facilities, traffic on roads, increased presence of workers/contractors within communities all tend to affect people's perception more than a 'traditional' sense of risk. This type of concern includes local economic affects and *loss of affluence* e.g. decreases in house prices.

Communities also require a sense of equity where there is a sense that affected people are excluded from opportunities i.e. jobs going to others or being populated by a migrant workforce.

4.4 *EMERGENCY RESPONSE*

People tend to accept that *'accidents can happen'*, yet worry about not knowing what to do in an emergency or should they hear an alarm.

In one case where a community was very resistant to the development of a new installation, there was an acceptance that an accident might happen, but the concern was that an increase in traffic (as a result of the new development) might slow emergency services in attending the scene.

4.5 *KNOWLEDGE*

A recent UK based social engagement project related to emergency planning for a major O&G organisation showed that as facilities become more automated and less people from within communities work there, less people *'know how it works'* i.e., people are less knowledgeable and/or familiar with major hazard installations and how they operate. This tends (as has been seen in research) to increase people's concern/aversion to risk.

Public 'outrage' is affected and can be amplified by the method and means adopted by experts and organisations in relation to stakeholder engagement. It is linked with a sense of fairness and equity and can be amplified by observed 'unfairness' in how blame is apportioned when an incident takes place. People react more strongly where they sense that vulnerable groups are being exposed to risk or inconvenience e.g. children.

- This research has restricted its focus to finding '*evidence or otherwise of scale aversion in public reaction to major accidents*' and has found insufficient evidence of scale aversion to enable it to be represented in mathematical terms.
- It has found, however, a wide range of 'broader concerns' (Ball and Floyd 1997). Such factors have been seen to influence the perception of risk and should be considered in more detail in the development of any wider decision-making policy. These include everyday inconvenience (noise & nuisance); equity; the physical structure of a site (i.e. flumes, 'dangerous looking' tanks, flares etc) trust in specific organisations & 'experts'; control and vulnerability of affected groups (i.e. children).
- A consistent finding evident in the range of work reviewed is that people *do* worry about the impact of hazardous incidents/installations on their lives. However, the extent to which they worry, the nature of their concerns and the variables that influence their response and reactions are considerable. That said, people are affected by a wider sense of loss than that addressed by scientific calculations of risk which are based on harm to people. People worry about issues such as damage to their homes and businesses, decreased house values, compensation, what to do in an emergency and general disruption. A consideration of how the HSE might use current risk based advice (or elements of it) as a basis for providing additional information relating to other types of 'loss' as a result of major hazard incidents may be a means by which some of the elements that affect risk perception are addressed as part of a revised decision making framework.
- The extent to which people have a sense of control has been found to be a factor that affects risk aversion and perception. This has implications for any conclusions drawn from research that asks subjects to make a choice. There is a range of literature that aims to understand scale aversion by examining the economic/consumer choices that individuals make. A number of research studies adopt the 'willingness-to-pay' methodology that asks subjects to make decisions with regard to the investment they would make in order to control a range of risks. In examining reaction to major accidents (both actual and theoretical) the evidence suggests that aversion to social accident and disaster risks (as opposed to economical risks) is a far more complex phenomenon than is captured in the classic expected utility/prospect theory laboratory work (Enander and Lajksjo 2004)

- The notion of control must be considered when using conclusions from rail incidents to make judgements about the existence or otherwise of scale aversion, especially in the context of landuse planning policy. There is a fundamental difference in the extent to which people have control in these two cases. People choose to get on a train; they have a sense of what to expect when they pay to travel on public transport;; they know what to expect should something go wrong; they choose to expose themselves to the risk. It might be assumed that in the context of land use planning decision - making, that members of society may not be in a position personally to affect the risk of any hazardous installation. Applying an argument for or against scale aversion based on research that provides subjects with a choice and rail incidents where exposure to risk is to some extent within the control of the individual will miss this important distinction.
- Public reaction to major accidents is difficult to assess as the primary resource for doing so is the media which research has shown to be an amplifier of risk perception; it does not therefore provide an objective measure. Furthermore there is limited access to local news stories. Although in principle more work could be undertaken to access local news archives to assess reaction to incidents, it is considered that such an activity would be very time consuming and would be unlikely to prove cost-effective.
- Other than the council funded social impact assessment reviewed in this report, little work has been undertaken to assess the broader affects of the Buncefield explosion. It is clear that there has been a ripple effect in the impact of the event. Further research into this incident specifically may be beneficial.
- Although risk communication and trust in experts were only touched upon in this work, it is clear that they can affect people's perception of risk. It is recommended that any wider decision-making policy that relies in some part on the communication of expert risk calculations acknowledges this as a broader concern and considers how this might be effectively undertaken.

Annex A

Research Review Summary Table

Table A1.1 presents summary of the research review, giving in each case, the following information:

- Author
- Publication title or reference
- Argument / evidence
- Comments (where relevant).

Table A1.1 Research Summary Table

Author	Publication Title or Reference	Argument / Evidence	Comments
Adams, J. and Thompson (2002)	Taking account of societal concerns about risk: framing the problem	They argue that 'societal concerns' can be fruitfully explored via constructivist methodologies, and cannot be 'bolted on' to objectivist practices (p12). They advocate a move towards totally different tools for analysing 'societal concerns', which would include the concept of scale aversion, and related factors such as 'dread'. They recommend engaging in discourse analysis. The evidence given is an analysis of views found in the media surrounding the Brent Spa oil rig controversy, though this will not necessarily be helpful or representative as a vehicle for eliciting public views, but it does provide some evidence for scale aversion (see Appendix A.2, p35).	
Ball, D. J. and Floyd, P. J. (1997)	<i>Societal Risks</i> , Report for the HSE	Ball and Floyd argue it is difficult to elicit and incorporate into decision-making, the views of the public. They concede that values may be important but that these are time and effort to elicit (1997, p25). Jones-Lee, M. W. and Loomes, G. (1994) study quoted and forms main basis for evidence against scale aversion, but that research is not scrutinised. Authors favour a quantitative approach. They also suggest, where there is such a phenomenon as scale aversion, it would be qualitative and therefore dealt with separately to quantitative or technical aspects of risk.	Mixed evidence, authors favour a quantitative approach and separate engagement with more psychological aspect of risk perception.
Albert Bandura (1977)	Social Learning Theory	Psychology of social behaviour and learning	Second hand learning from the media
Botterill, L. & Mazur, N. (2004)	Risk & risk perception: A literature Review	The psychological aspects of decision-making defined (pV)	Mixed evidence, authors favour a non-mathematical approach.
Chilton, S. et al. (2002)	Public Perceptions of Risk and Preference-Based Values of Safety	The article reports two studies, one carried out after major disaster, and in that sample, respondents were dominated by a high number of individuals exposed regularly to that specific context (rail). They found a statistically significant upward shift in the priority given to rail safety after disaster. There was also heightened awareness of rail safety issues, and issues of blame, responsibility, moral outrage, hostility towards Railtrack. Authors state that this didn't translate into very sizeable quantitative valuations (however 20% seems quite significant). The 'number of deaths' dominates peoples' thinking here, though psychological affects and social amplification effects matter too.	Some evidence for post incident scale aversion

Author	Publication Title or Reference	Argument / Evidence	Comments
http://www.opsi.gov.uk/si/edm2005/uksiem_20051088_en.pdf	Explanatory Memorandum to the Control of Major Accident Hazards (Amendment) Regulations 2005 No.1088	Evidence for scale aversion – large scale incidents move institutions to make legislative change	
House of Lords, (2005-2006)	Government Policy on the Management of Risk	Various arguments against scale aversion, but the evidence cited is (mainly) from research by Jones-Lee, M. W. and Loomes, G. (1994) and that survey actually provides some evidence for scale aversion, as well as being potentially 'leading'.	
Jones-Lee, M. W. and Loomes, G. (1994)	Valuing Safety in Transport Project Appraisal	The argument is intended to be against scale aversion, and research provides evidence against, however if scrutinised the research methodology is leading, and the results even provide some evidence for scale aversion.	
Jones-Lee, M. W. and Loomes, G. (1995)	Scale and Context Effects in the Valuation of Transport Safety	The same study as above (1994) is referred to. The methodology is not explained in this piece, the argument is against scale aversion and the results are quoted to provide evidence against scale aversion.	
Linnerooth-Bayer, J. (1993)	The Social Mismanagement of Risk? Risk Aversion and Economic Rationality	Theoretical arguments for collective-fatality aversion, for example that 'a coin is flipped for the entire group determining to varying degrees the risk to each participant' (Linnerooth-Bayer, 1993, p5) and this reduces individual control and increases risk perception.	
Lofstedt, R. E. (1997)	Risk Evaluation in the United Kingdom: Legal Requirements, Conceptual Foundations, and Practical Experiences with Special Emphasis on Energy Systems	<p>'Criticisms of ALARP stem from the fact that it is doubtful that the quantitative evidence is likely to be perfectly comprehensive, and that to some extent decisions have to be based on qualitative evidence' (p25). Political risks and 'popular' (media hyped) risks get greater safety investment than is strictly, numerically required under ALARP.</p> <p>Due to the lack of public participation in the policy making process, environmental NGOs have become an indirect conduit for public opposition particularly on issues of siting energy installations and roads (p153). In the Sizewell B Inquiry, for instance, the strongest opposition to the building of the nuclear power plant came from environmental NGO's and in the case of THORP Greenpeace has been the most vociferous critic of its building and operation (p52).</p>	Some evidence for scale aversion.

Author	Publication Title or Reference	Argument / Evidence	Comments
National Platform for Natural Hazards, Switzerland, (2007)	Risk Aversion: development of instruments for risk and safety assessment associated with natural and technological hazards	The existence of scale aversion is assumed, and evidence is not referenced. Attempts are made to integrate scale aversion into FN curve using gradients and functions.	Authors want to integrate psychological reactions to large scale incidents into quantitative methods of risk assessment.
Plapp, T. and Werner, U. (2006)	Understanding risk perception from natural hazards: examples from Germany'	Risk perception defined as an everyday activity, based on experience, without complex models. It is an 'unconscious', 'value judgement', which is 'intuitive' (p101). Risk defined correspondingly, as multi-dimensional concept, social, cultural & historical context, following Renn 1995. Experience: the perceived riskiness of floods corresponded to incidence of floods. Where there was perceived 'little scope for action or response' and 'the consequences' were crucial in risk rating (p105) & lack of ability to predict/prepare/warn. Influences on risk perception (p107) Cues garnered from scientists matter (p108).	
Sandman, P. M. et al., (1993)	Agency Communication, Community Outrage, and Perception of Risk: Three Simulation Experiments	Summarising Mazur, (p2) Sandman states that the frequency of media reporting makes risk seem more likely. 'Outrage' or the nontechnical aspects of risk determine public assessments. Trust and secrecy correlated with higher risk perceptions in mock newspaper stories about industry accident type stories. Respondents felt frightened of the risk and unsafe when the spokesperson seemed untrustworthy / secretive and the community, outraged. Identical technical information was included in both stories (p7). Prolonged exposure to a risk controversy makes people more responsive to outrage & less responsive to seriousness and technical detail, ie. raises risk perception (p15) 'Outrage' is not a single variable but a cluster of other things (p15).	
Sjoberg, L. (1999)	Risk Perception by the Public and by Experts: A Dilemma in Risk Management'	Expert / Public differences in risk perception explored, explanatory factors given, such as; background data like gender, education, age. Additionally: Realism (but not all experts agree); Different definitions of risk, experts attend to probability whereas the public focuses on consequences, perceived control / familiarity, professional role, agenda, general political ideology, media contents, trust (p5).	

Author	Publication Title or Reference	Argument / Evidence	Comments
Slovic, P., Fischhoff, B., and Lichtenstein, S., (1979)	Rating the Risks	Facts go only so far, human judgement interprets. Heuristics are used, especially 'availability', that is, if an event is easier to imagine or recall, risk perception is higher. Recent or vivid events are more available, therefore seem riskier. Risks from rare causes of death were overestimated and common causes underestimated. For example, accidents were judged to cause as many deaths as diseases but actually diseases take around 15 times more lives. Similarly with homicides and strokes. Dramatic and sensational events perceived as more risky (p1-2). Experts also use judgements and arguably their results produce overconfident assertions (p4). When assessing risk, people are not just thinking of the number of people it could kill but also the more qualitative aspects of that risk. Risk perceptions of nuclear power, compared to mountain climbing depend on groups asked - e.g. industry group worry less about nuclear risk. Nuclear power had the lowest fatality estimate but the highest perceived risk, so fatalities are not the issue for the public (p20). Nuclear and explosive substances considered high risk because of potential for disaster (p20). Control matters; risks faced voluntarily were less risky (p22)	Some evidence for scale aversion
UK Government, RIA	Proposals for revised policies to address societal risk around onshore non-nuclear major hazard installations	The aim of this paper was to explore the wider issue of how to account for societal risk in the management of all major hazard sites (excluding nuclear and pipelines). To avoid over-emphasis on Buncefield type sites, the RIA for land use planning around large petroleum storage sites considered only individual risk – it did not attempt to take in to account societal risk.	
Wahlberg, A. and Sjoberg, L. (2000)	Risk perception and the media	more media attention = higher risk perception regardless of the information in the reports they remind us of the issues (p40). Perceptions are far from stable, and are often mood related (p43). Facts do not necessarily affect opinions (summarising Baird 1984) Already existing views matter more (p38)	
Weber, E. U. et al., (2002)	A Domain-specific Risk-attitude Scale: Measuring Risk Perceptions and Risk Behaviours	People are not consistently risk averse / accepting across different domains - context affects perception of risks and benefits rather than affecting willingness to take risks. Therefore interactional model of risk taking adopted, whereby situational and person-centred characteristics jointly influence risk perception (p283)	

Annex B

Case Study Evidence

Table B1.1 Case Study Evidence summary

Author	Title/reference	Evidence
Bennett, S. (1999)	Disasters as Heuristics? A Case Study	Paper explains the changing risk perceptions of the Baglan Action Group (BAG) following the Flixborough disaster. During the early 1970s the members of a local environmental group in Port Talbot, South Wales began complaining about the environmental and health record of a local petrochemicals plant. It was alleged that the plant generated dust, noise and light pollution, and 'odours'. Concern was also expressed about the use of vinyl chloride monomer, a suspected carcinogen, as a feedstock gas. The plant's explosive hazards were not a major bone of contention until after the disaster.
BBC News Online	Your initial reaction to London's rail disaster http://news.bbc.co.uk/1/hi/uk/465764.stm	'...the average Londoner pays app.£1000 pa to travel like a piece of cold meat' 'May this never happen again' 'When are the government going to take heed that our railway system is probably more dangerous than travelling by car...' 'Frankly, I AM FURIOUS THAT SUCH A CRASH CAN HAPPEN AGAIN...'
Fire at BP Oil, Grangemouth, 13 th March 1987.	See: http://news.bbc.co.uk/1/hi/scotland/tayside_and_central/7393683.stm and: http://scotlandonsunday.scotsman.com/scotland/Grangemouth-fire.4071605.jp http://www.lpgasmagazine.co.uk/old-lpgas-magazine-site/as05_1.html	Generally, media coverage dominated by concern with small fire in May 2008, and strikes regarding pension scheme changes. That coverage did not recall the previous, big incident. Though other coverage referred to incidents in 2000, HSE concern, the threat to the community (http://findarticles.com/p/articles/mi_qn4156/is_ai_n12583918) LPG Magazine coverage was more technical
Phillimore, P. and Moffatt, S. (2000)	'Industry causes lung cancer would you be happy with that headline?' Chapter 6, in Allan et al., <i>Environmental Risks and the media.</i>	Case of ICI & British Steel's links to air pollution on Teeside. Evidence suggesting local paper and population influenced by industry and local council interests, therefore against scale aversion as such, because only after the national press re-ignited the issue was there something akin to scale aversion (outcry).

Author	Title/reference	Evidence
Salvi, O. and Dechy, N. (Ineris, French Government)	Toulouse disaster prompts changes in French risk management	A terrible explosion of ammonium nitrate, causing 30 fatalities and an estimated 10,000 injuries, occurred on 21 September 2001 at the AZF plant in Toulouse operated by a Total subsidiary. The accident consequently caused very serious destruction, damaging some 27,000 dwellings ² . Estimates issued by national and local authorities indicate that 10,000 people were injured (physically). A further 14,000 people applied for medical treatment for acute post-traumatic stress in the months following the explosion. The Toulouse disaster prompted nationwide debate, leading to a new law to improve risk management (2003-699). It introduced a significant change to the prevention of technological risks. The second part of the law reflected lessons learned from recent floods and natural disasters (flooding caused by the Somme, Gard and Hérault rivers). The disasters at Enschede and Toulouse reminded Europe that the control-based Seveso II directive (in particular its Safety Management System requirement) was not enough to prevent major accidents turning into disasters. Moreover the trend for major accidents recorded in the European Commission's MARS database (EC, 2002) indicates an annual EU average of roughly 30 to 40 major accidents (1995-1999).
Fire at Allied Colloids Limited, Low Moor, Bradford, 21 st July 1992.	See: http://www.highbeam.com/Search.aspx?q=Allied+Colloids+Fire and: http://www.google.com/search?hl=en&q=Allied+Colloids+Fire+News&btnG=Google+Search	News coverage is dominated by financial news and specialist industry coverage.
Chemical Release and Fire at the Associated Octel Company, Ellesmere Port on 1 st nd 2 nd February 1994	See: http://www.google.com/search?hl=en&q=Associated+Octel+Company+Fire+News&btnG=Search and: http://www.google.com/search?hl=en&q=%22Associated+Octel+Company+Fire%22&btnG=Search	News coverage is dominated by specialist technical coverage.

Author	Title/reference	Evidence
Explosion and fires on the Pembroke Cracking Company Plant at the Texaco Refinery, Milford Haven, 14th July 1994.	See: http://www.google.com/search?hl=en&q=Pembroke+Cracking+Company+Plant+Fire&btnG=Search And: http://www.google.com/search?hl=en&q=%22Pembroke+Cracking+Company+Plant+Fire%22	Technical industry coverage dominated the results, with little media coverage. Local newspaper archives extended only top 2003. However, more recent local coverage revealed attention to a recent (March 2005) incident at the plant, concern about risk, sense of lack of control was considerable, and links were drawn between large scale incidents in other countries (http://archive.milfordmercury.co.uk/2005/3/31/526.html)

Annex C

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