The Impact of Catastrophes on Shareholder Value

Rory F. Knight & Deborah J. Pretty

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1. The impact of catastrophes

On 11 May, at around two pm Eastern time, ValuJet DC-9 Flight 592 bound for Atlanta crashed into the Florida Everglades soon after take-off from Miami. All passengers and crew perished. This was a human catastrophe beyond comprehension. The financial consequences may also turn out to be catastrophic for the relatively young airline. The study of the financial consequences of catastrophes may seem morbid. However, catastrophes are phenomena which provide a unique opportunity to evaluate how financial markets respond when major risks become reality.

In formulating risk management policies, corporate managers have to evaluate alternative strategies against the criterion of shareholder value maximisation. Thus, a decision to hedge against certain types of risk should hinge on whether the value of the firm is higher or lower under hedging. In order to assess the benefits of catastrophe insurance in value terms, a deeper insight is called for into how catastrophes affect shareholder value and how the existence of catastrophe insurance influences their impact. Preliminary findings indicate that the impact of catastrophes on shareholder value is not strongly influenced by the existence of catastrophe insurance. Catastrophes appear to affect value in rather complex ways which seem to result in a re-evaluation of management - which may be positive or negative. This result is largely consistent with modern financial theory which suggests that shareholder value is based on *ex ante* risk assessments in the context of large portfolios. In such a setting, much of the idiosyncratic risk associated with a particular company is diversified away. Further hedging of risk by management may be redundant from the view of shareholders.

It is too early to say what the full effect of the ValuJet tragedy will be on shareholder value. However the prognosis emerging from this study is bleak. ValuJet bears all the hallmarks of a "non-recoverer". Firstly, the shareholder value lost in the first few days was massive, amounting to about 35% of market capitalisation - putting it on a similar scale to Union Carbide's Bhopal incident. Secondly, the potential cash flow impact is enormous - probably in the region of $308 million. Thirdly, there were a high number of fatalities: all 110 passengers and crew members perished. Finally, it appears that management will be judged to be at least partially responsible for the safety lapse. All of these four factors have been identified as key determinants governing the shareholder value response to catastrophes.

This briefing aims to identify the impact of catastrophes by focusing on fifteen major corporate catastrophes and tracing their impact on shareholder value. As would be expected, in all cases the catastrophe had a significant negative initial impact on shareholder value. Figure 1 shows the average impact of all the catastrophes on shareholder value. But after a sharp initial negative impact amounting to almost 8% of shareholder value, there is on average an apparent full recovery in just over fifty trading days. This suggests that the net impact on shareholder value is negligible. However, as will be shown below, the ability to recover the lost shareholder value over the long-term varies considerably between firms.

Figure 1: Impact of Catastrophes on Shareholder Value (Full Sample)
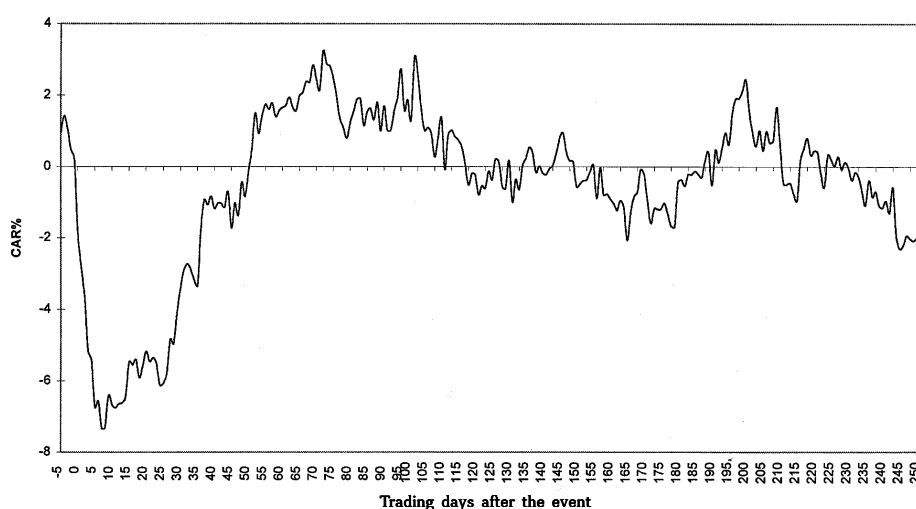
In addition to the direct impact on shareholder value, catastrophes also have a highly significant impact on the level of trading in shares. Figure 2 shows that trading in shares in these corporations is more than four times the usual level in the days immediately after the catastrophe. On average, trading settles down to normal levels around a month afterwards. Thus, the immediate and negative impact on value not surprisingly coincides with abnormally high levels of trading activity. By contrast, the drift back in shareholder value occurs at a normal level of trading activity.

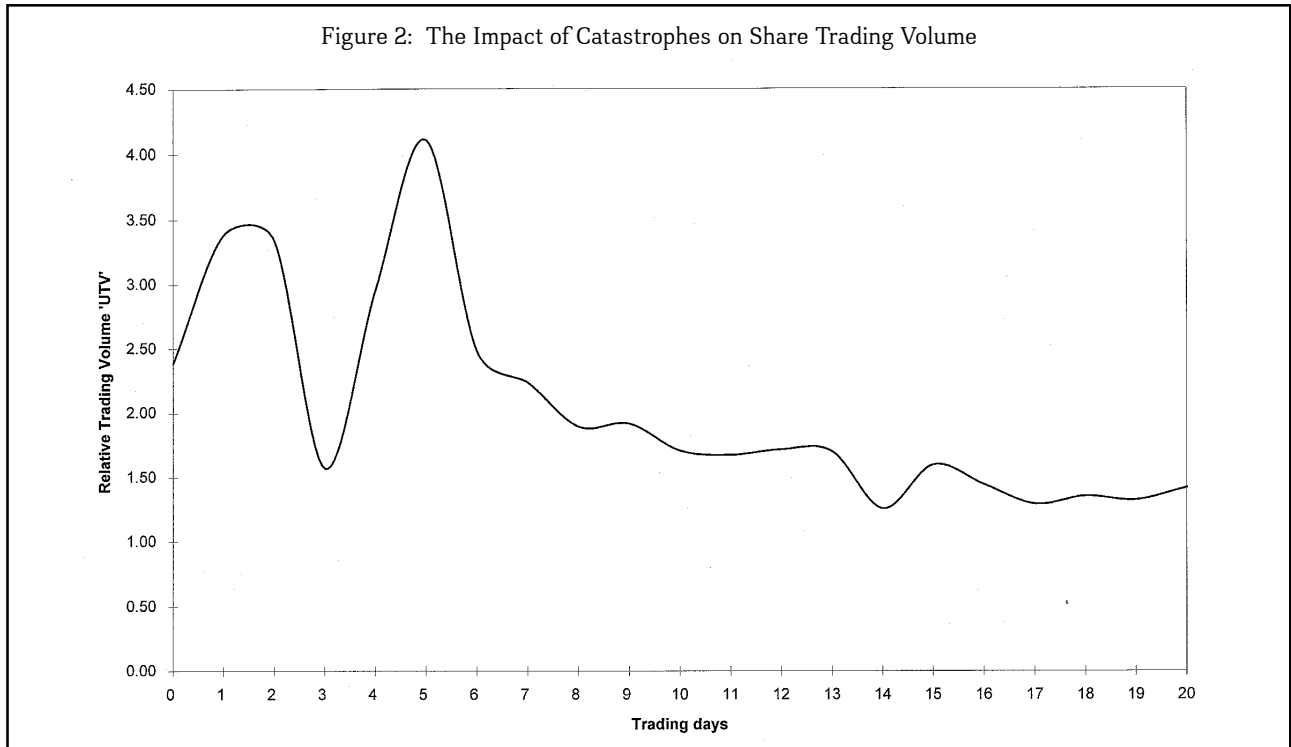Figure 2: The Impact of Catastrophes on Share Trading Volume

Figure 3 illustrates the impact of catastrophes on the volatility of share returns indicating that, although volatility increases initially, it does settle down soon after the event. This result suggests that no significant sustained impact on share volatility is induced by catastrophes.

Figure 3: The Impact of Catastrophes on Share Volatility

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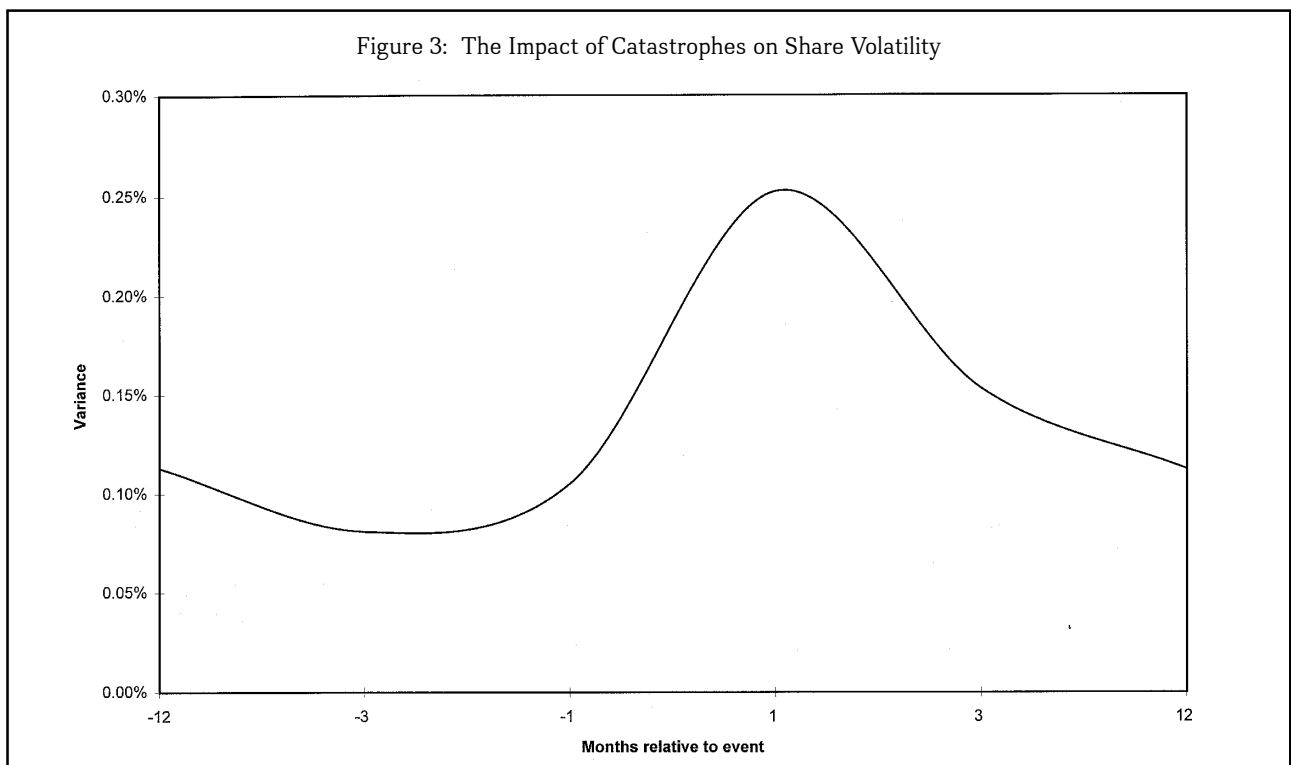
2. Why do some firms recover from loss in shareholder value better than others?

Interestingly, firms affected by catastrophes fall into two relatively distinct groups - recoverers and non-recoverers. The initial loss of shareholder value is approximately 5% on average for recoverers and about 11% for non-recoverers. Figure 4 shows that by the fiftieth trading day, the average cumulative impact on shareholder value for the recoverers was 5% plus. So the net impact on shareholder value by this stage was actually positive. The non-recoverers remained more or less unchanged between days 5 and 50 but suffered a net negative cumulative impact of almost 15% up to one year after the catastrophe.

Figure 4: Recoverers vs Non-Recoverers

Figure 5: Trading Volume of Recoverers vs Non-Recoverers
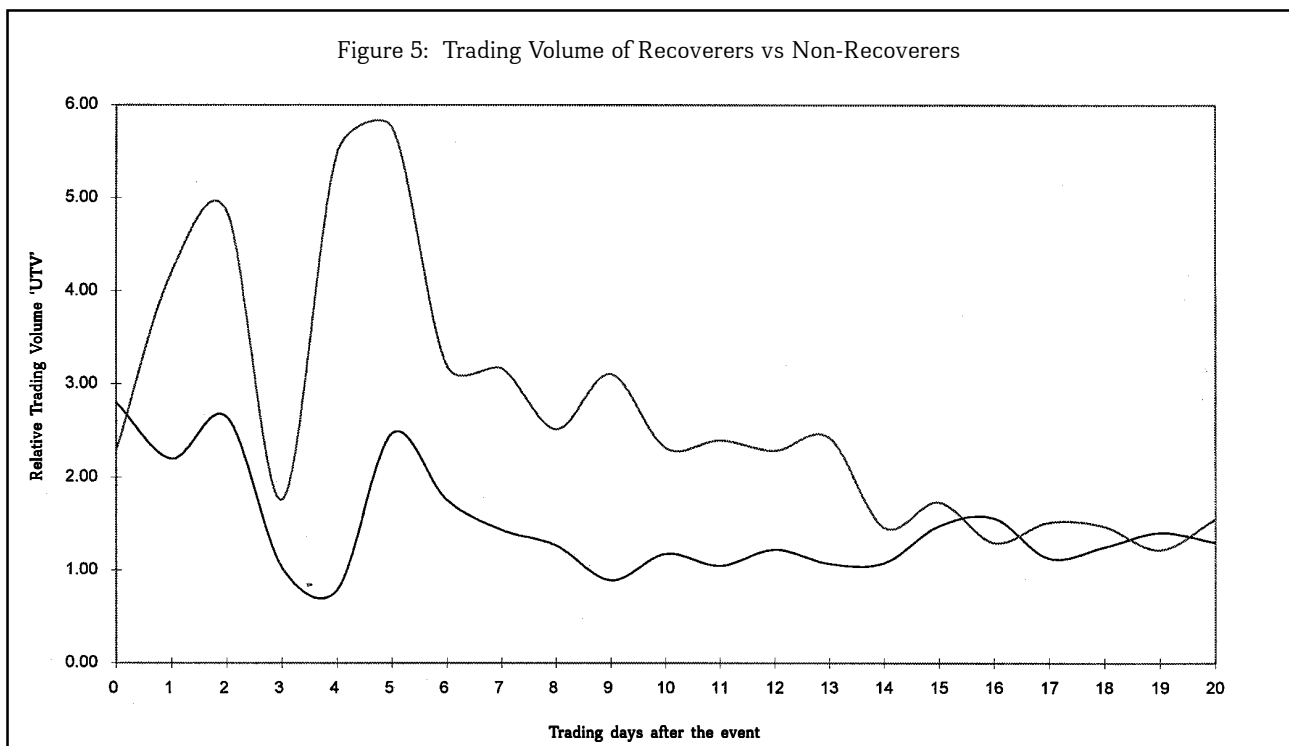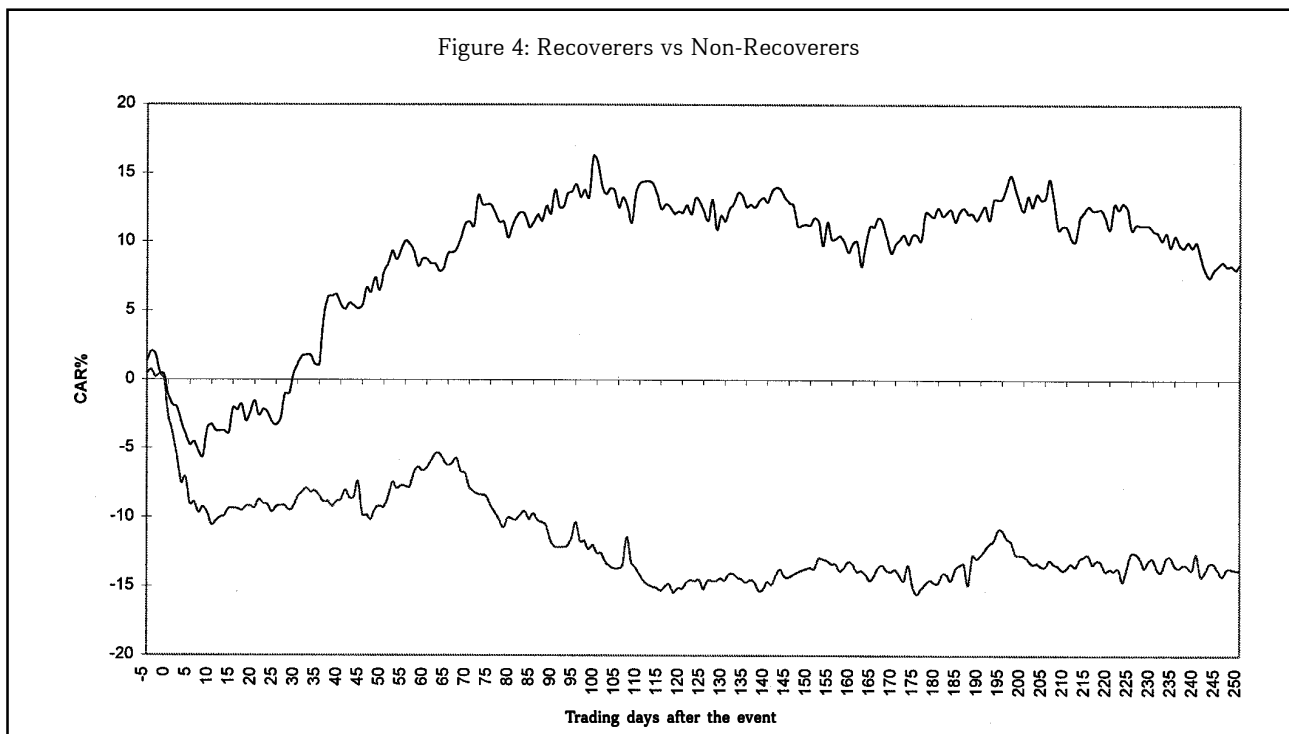
Why would some catastrophes lead to an increase in shareholder value? One explanation from our research is that there are two elements to the catastrophic impact. The first is the immediate estimate of the associated economic loss. The second hinges on management's ability to deal with the aftermath. Although all catastrophes have an initial negative impact on value, paradoxically they offer an opportunity for management to demonstrate their talent in dealing with difficult circumstances. Effective management of the consequences of catastrophes would appear to be a more significant factor than whether catastrophe insurance hedges the economic impact of the catastrophe. Figure 5 shows that the abnormal trading (shown earlier in figure 2) is predominately caused by non-recoverers. Thus, an absence of frenetic trading around the time of a catastrophe is usually associated with a subsequent recovery in shareholder value. Interestingly, the research reveals that the volatility impact is almost identical for both recoverers and non-recoverers.

SELECTED RECOVERERS

	CAR at 50 trading days	CAR at 6 calendar months
Pan Am	50%	40%
Comm Union	13%	22%
Heineken	4%	13%
J&J 1986	8%	11%
Phillips	4%	6%
Sandoz	-11%	4%
Upjohn	-1%	-1%
P&O	-4%	-2%

CAR = Cumulative Abnormal Returns

SELECTED NON-RECOVERERS

	CAR at 50 trading days	CAR at 6 calendar months
Eli Lilly	1%	-5%
Occidental	-1%	-6%
Shell	-6%	-11%
Perrier	-5%	-16%
J&J 1982	-10%	-18%
Exxon	-15%	-18%
Union Carbide	-29%	-29%

The essential distinctions between recoverers and non-recoverers appear to be that:

- There is among non-recoverers an initial negative response of over 10% of market capitalisation.

- In the first two or three months the magnitude of the estimated financial loss is significant among non-recoverers.

- There is a large number of fatalities. This seems to govern recovery in the first two or three months.

- Thereafter, the issue of management's responsibility for accident or safety lapses appears to explain the shareholder value response.

By contrast, whether the losses were fully covered by insurance does not appear to have much influence.

3. What are the implications for the insurance markets?

This research presents evidence which suggests that a firm's recovery of shareholder value immediately following a catastrophic loss is independent of the presence of insurance cover. This raises interesting issues for the consumers (companies) and the providers (insurers and brokers) of risk management services.

The empirical results we present suggest that the impact of a catastrophe on shareholder value derives from two sets of factors. The first is the direct financial consequences of the catastrophe. What will be the impact of the catastrophe on the firm's future cash flows? Although the cash flow impact is not known with certainty at the time of the catastrophe, the stock market will form a collective opinion and adjust value accordingly. These direct factors will usually have a negative impact on shareholder value, but this impact will be cushioned by the extent to which insurance recoveries reduce the cash outflows.[1]

The second set of factors are what may be described as the indirect factors. These factors have an impact on shareholder value which springs from what catastrophes reveal about management skills not hitherto reflected in value. A re-evaluation of management by the stock market is likely to result in a re-assessment of the firm's future cash flows in terms of both magnitude and confidence. This in turn would have potentially large implications for shareholder value. Management is placed in the spotlight and has an opportunity to demonstrate its skill or otherwise in an extreme situation. The indirect factors are therefore able to have a large negative or positive impact on value.

The combined effect of the two sets of factors could therefore be either positive or negative: positive in circumstances where the benefits of what is revealed about management outweigh the net financial loss of the catastrophe; unfavourable if the revelation effects are negative, since this will amplify the negative impact of the financial loss.

[1] In some circumstances the impact could be positive. For example, where the demand for a firm's products increases (with the attendant increase in cash flow) as a result of consumer sympathy flowing from the catastrophe. In the context of the current classification such effects should be defined as indirect, ie within the second set of factors.

The results of this study suggest that it is the indirect factors which dominate the impact of catastrophes on shareholder value. The net financial loss has a relatively minor impact on the full change of shareholder value associated with catastrophes.

The message is clear: catastrophe insurance cover is no protection against the shareholder value effects of catastrophes. This suggests that a company's insurance strategy should not be considered in isolation and should not be viewed as a substitute for high quality risk management and contingency planning systems and procedures.

The results further suggest that there may be considerable demand from the corporate sector for the unbundling of traditional insurance products in future. Frequently the insurance premium paid by a corporate includes a fairly modest element to cover a catastrophic loss, the balance of the premium relating to claims handling and management services. In addition there appear to be significant opportunities on the supply side for the insurance providers to expand their services in the latter end, namely by providing more extensive risk management and catastrophe management services. There appears from these results to be considerable value adding potential in this domain.

An unbundling of the insurance products would allow firms to disentangle their decision to insure losses from their decision to purchase risk management services and claims handling.

The results suggest that the financial loss is a small part of the value effects of a catastrophe. The crisp issues facing management are:

1. Is the insurance cover value for money?

2. Is there any value in outsourcing the management of catastrophes?

The varying responses to these issues will shape the demand for insurance services.

The value of insuring the financial loss is being questioned seriously by many firms. What are the benefits to well diversified shareholders who also hold shares in insurance companies? At best a zero-sum game perhaps? There are unlikely to be any free lunches on offer from the insurance industry. British Petroleum's historic decision to retain the bulk of its

exposures, including catastrophe exposure, is an example of this logic. Interestingly, BP management continues to purchase risk management services from the insurance industry. The results presented here seem to indicate that more corporates may adopt this approach in future.

Another trend evident in the last decade has been for large industrial corporations to adopt captive and/or self-insurance whilst continuing to purchase catastrophe insurance cover. This is in sharp contrast to the BP philosophy in that these corporates have perceived value in the cover but not the service. This presents the insurance industry with considerable opportunities and threats. Considering the results of the study it is likely that the opportunities could be larger than the threats for the responsive and innovative.

On the supply side, the response of the global brokers to the changes in the purchasing and risk management philosophy of their major clients has been to move progressively away from a transaction-based culture, with remuneration by brokerage, towards the provision of an increasingly wide range of risk management, insurance and consultancy services, remunerated by fees for work undertaken and added-value provided. These results support the wisdom of such a strategy.

Finally, an additional response to the changing patterns of behaviour seen recently in the commercial insurance markets has been the establishment of Bermuda-based catastrophe reinsurance ventures. In 1992-93 these companies attracted more than US$4 billion of capital in the private and public markets. Recent years have seen also a marked growth in hybrid funding mechanisms such as the catastrophe futures and options traded in Chicago. It is possible that these new instruments will have other ramifications for post-catastrophe share price response.

Selected Case Studies

The selection of corporate catastrophes which follows is based on four criteria:

1. The disasters are man-made as opposed to natural.

2. Each involves a publicly-quoted company.

3. Each has received headline coverage in world news.

4. Each has occurred since 1980.

In addition, in each case the organisation is affected on a symbolic level as well as on a physical level. Moreover, this symbolic impact affects the whole organisation and is not limited to a self-contained unit.

| Date	Company Name	Catastrophe	Type of Catastrophe	Financial Estimate (US$)
30/09/82	Johnson & Johnson	Tylenol	Product tamper & recall	150m
03/12/84	Union Carbide	Bhopal	Liability	527m (min.)
11/02/86	Johnson & Johnson	Tylenol	Product tamper & recall	150m
01/11/86	Sandoz	Rhine	Fire & pollution	85m
06/03/87	P&O	Zeebrugge	Liability	70m (min.)
05/05/88	Shell Oil	Norco	Explosion & fire	706m
06/07/88	Occidental	Piper Alpha	Fire & explosions	1,400m
21/12/88	Pan Am	Lockerbie	Terrorism	652m
24/03/89	Exxon	Valdez	Pollution	11,500m (max.)
19/09/89	Upjohn	Halcion	Liability	23m
23/10/89	Phillips Petroleum	Pasadena	Explosion & fire	1,300m
10/02/90	Source Perrier	Benzene	Product recall	263m
17/07/90	Eli Lilly	Prozac	Liability	0
10/04/92	Commercial Union	Baltic Exchange	Terrorism	2,170m
25/08/93	Heineken	Glass	Product recall	10-50m

Six of the disasters profiled were in the oil/petrochemical/chemical industries, and six were product-related incidents. Overall, four events were attributable to deliberate acts of tampering or terrorism, and in a further two sabotage was suspected. Eight of the fifteen catastrophes occurred during the period 1988-90, which is consistent with the results of Lloyd's of London, the largest single provider of catastrophe insurance world-wide. Eight of the companies are American and the remaining six are European - British, Dutch, French and Swiss. Thus, this catastrophe portfolio is international and constitutes a representative sample across industries and across the major classes of loss world-wide.

Everglades Air Crash
ValuJet, 11 May 1996

Soon after taking off from Miami Atlanta-bound ValuJet DC-9 592 crashed into the Florida Everglades. Although the exact cause of the crash is unknown, investigators believe that a fire broke out in the forward cargo hold, which was carrying a consignment of inflammable airline oxygen generators and tyres, and that this fire was intense enough to break through to the passenger cabin. 110 people were killed: all 105 passengers and 5 crew members on board. On 13 May Standard & Poor's placed ValuJet's "BB" corporate credit rating and "BB-" senior unsecured rating on CreditWatch with negative implications, owing to the potential for lost passenger revenue. On 18 May ValuJet cut its number of flights - normally 320 daily - by half to check the safety of its aircraft. The hull value of the 27-year-old DC-9 aircraft is US$4m, for which
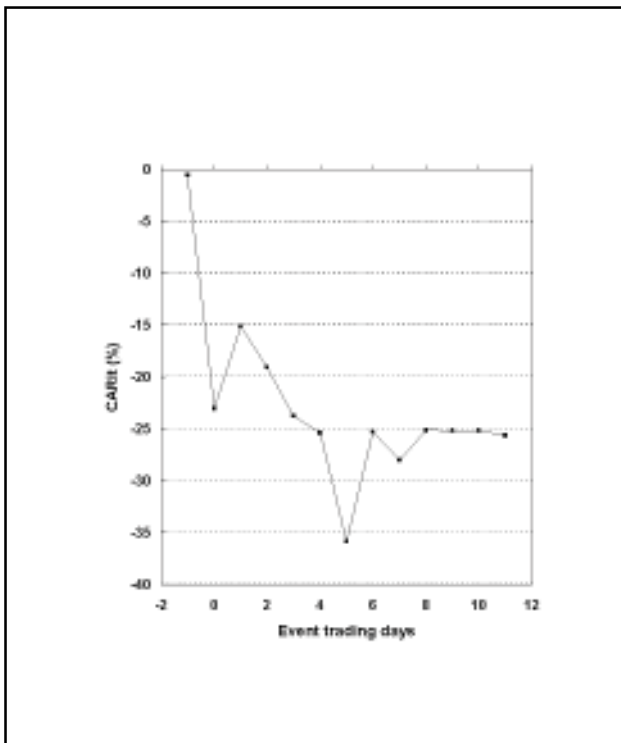

ValuJet is insured. It is estimated that ValuJet may have to pay as much as US$300m in liability claims; the company has liability insurance totalling US$750m for any one occurrence. By 20 May ValuJet had refunded approximately US$4.1m to passengers whose flights were cancelled or whose travel plans had changed as a result of the disaster. The maximum total cost of the air crash is estimated at US$308.1m.

Tylenol Poisoning I
Johnson & Johnson, 30 September 1982

It is believed that an employee or former employee of McNeilab, Inc - a unit of Johnson & Johnson - injected cyanide into Tylenol (acetaminophen/
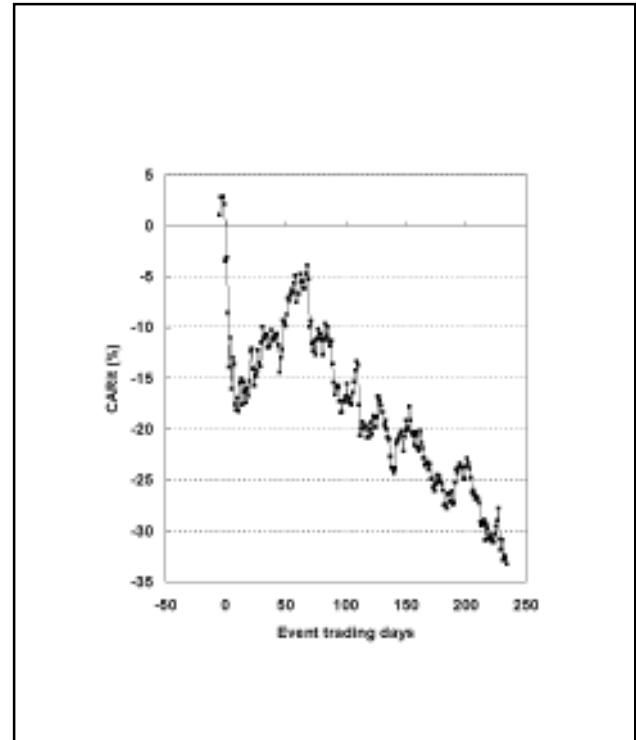

paracetamol) extra-strength pain relieving capsules. Seven people died of cyanide poisoning; all victims in the Chicago area. 31m bottles of Tylenol capsules were recalled, examined and destroyed. Sales of extra-strength Tylenol capsules were stopped and advertising halted. On 13 May 1991, the families of the seven victims reached an out-of-court settlement, the amount of which was not disclosed. On 13 January 1983, Johnson & Johnson sued its insurers US$67.4m in liability claims for the cost of recall - estimated at US$100m - and US$50m for business interruption losses. Johnson & Johnson insures the first US$5m of its product liability exposure through its captive insurer, Middlesex Assurance Company. On 22 September 1986, a US federal judge ruled that Johnson & Johnson's product liability insurance did not cover the costs associated with the Tylenol recall.

## Bhopal Gas Leak
Union Carbide, 3 December 1984

Poor safety measures, the storage of large quantities of lethal gas (methyl isocyanate) at the wrong temperature, the accidental or deliberate introduction of water to one of the gas storage tanks, confusion in detecting a rise in pressure in the tank and ineffective response to its detection - all these factors are believed to be responsible for the gas leak tragedy at Union Carbide's chemical plant in Bhopal, India. Union Carbide has always refused to accept full responsibility for the disaster - though it accepted "moral responsibility" from the outset - maintaining that sabotage by a disgruntled employee was the main cause of the disaster. The actual death toll from the Bhopal tragedy is undetermined. The most accurate estimate appears to be that over 3,000 people died and over 300,000 were injured. About 2,000 animals are estimated to have died and 7,000 were injured severely. Vegetation was destroyed in surrounding areas. Many people exposed to the gas will face a lifetime of ill-health with eye and lung disorders. Known costs, including liability charges and payments to build hospitals, exceed US$527m. By 12 March 1991 Union Carbide had collected US$167m in insurance from the disaster.
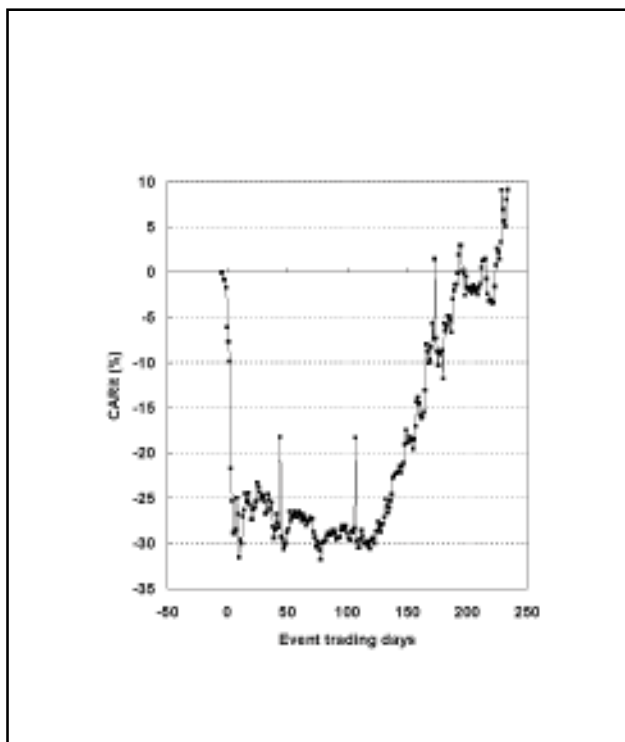
Tylenol Poisoning II
Johnson & Johnson, 11 February 1986

A woman died in Bronxville, New York, after taking cyanide-impregnated Tylenol (acetaminophen/ paracetamol) capsules. On 12 February 1986, the United States suspended sales of Tylenol capsules,
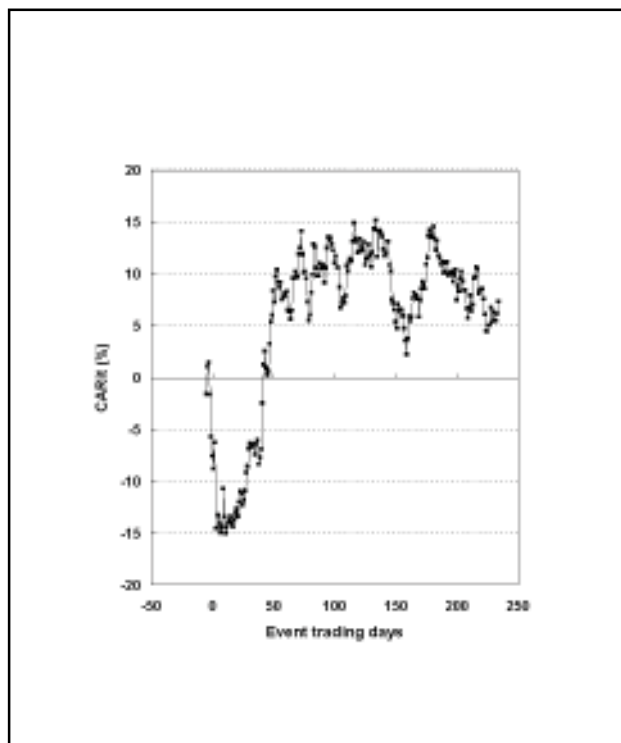

and on 3 March 1986 the sale of the drug was halted in a further 14 countries. On 17 November 1988 a United States district judge ruled that neither Johnson & Johnson nor the grocery which sold the cyanide-laced capsules was liable, and acquitted the companies of negligence. The cost of the recall is estimated at US$150m.

Rhine Pollution
Sandoz, 1 November 1986

It is alleged that the fire and explosion at the chemical warehouse of Sandoz at Schweizerhalle in Basle, Switzerland was probably caused by the use of a flame to shrink-wrap plastic covers around pallets of paint. These may have smouldered for several hours before bursting into flame. Sandoz believes the fire may have been the result of an arson attack. Fourteen people were injured and a cloud of poisonous gas was released into the atmosphere. Water used to fight the fire washed 30 tonnes of toxic chemicals into the River Rhine, turning it red
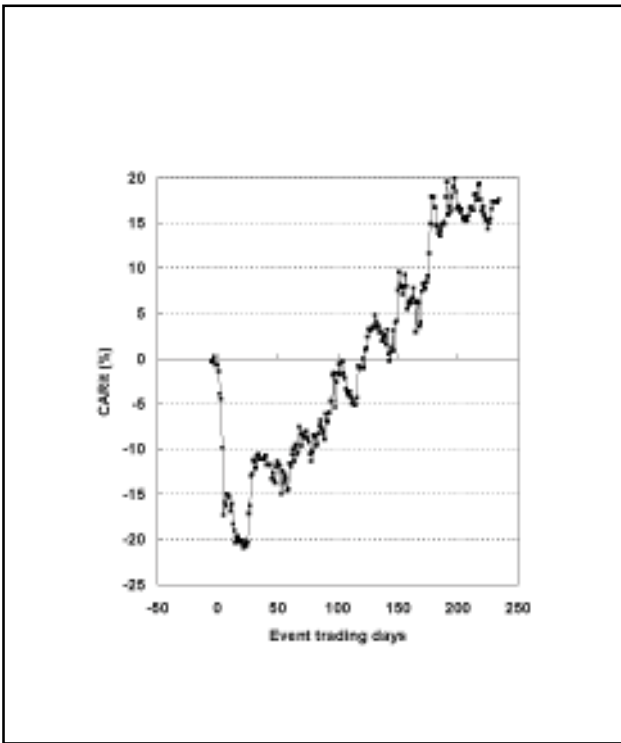
The Herald of Free Enterprise roll-on roll-off car ferry sailed from Zeebrugge harbour with its inner and outer bow doors open. It capsized and sank as a direct result of water rushing through its open bow doors. 192 people drowned: 154 passengers and 38 crew out of a total 454 passengers and 80 crew. Known legal costs total US$70m, but some active lawsuits remain.

Norco Explosion
Shell Oil, 5 May 1988

The Norco refinery and chemical plant exploded after hydrocarbon gas escaped from a corroded pipe in a

and killing thousands of fish. Loss of the warehouse and the 800 tonnes of chemicals which were stored inside is estimated at US$12m, with an additional US$6m required for clean-up of the warehouse. For these damages Sandoz is covered by insurance. It is estimated that Sandoz will pay US$67m in liability claims. The company is believed to have liability insurance totalling between US$67m and US$325m.

Herald of Free Enterprise Sinking
*P&O, 6 March 1987*
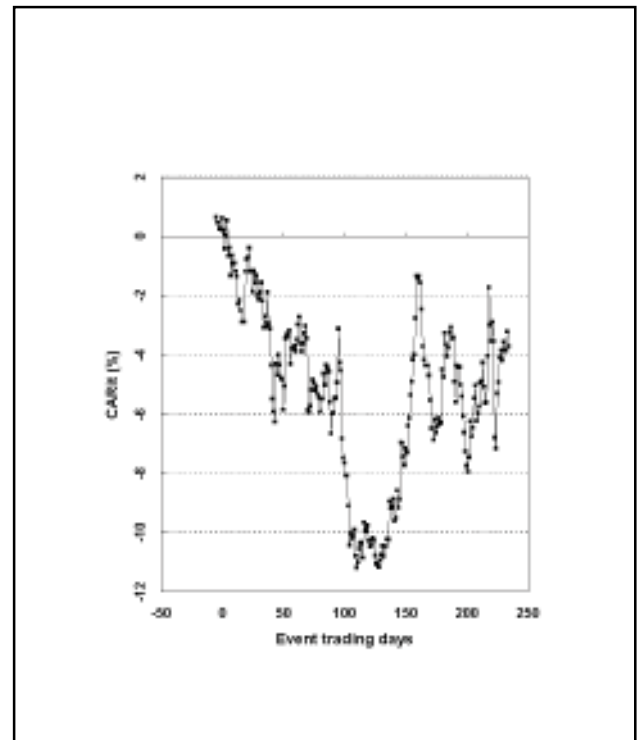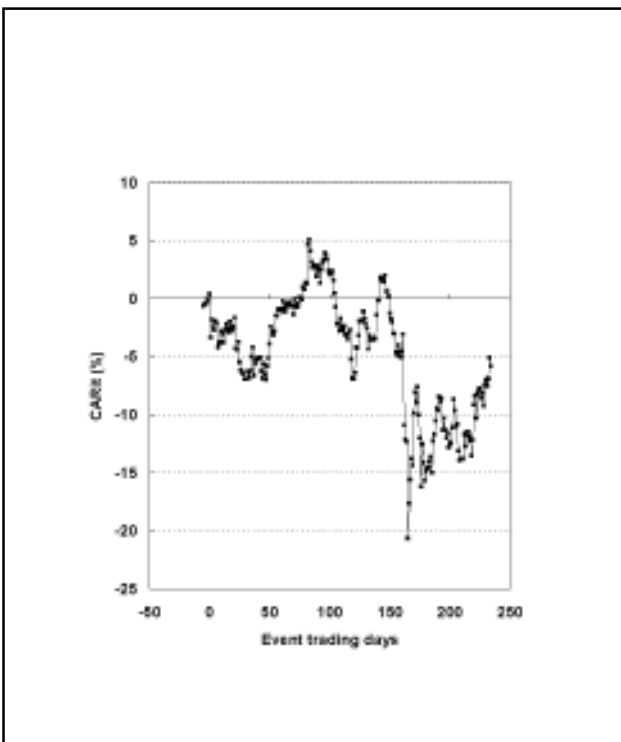
catalytic cracker and was ignited. Louisiana state police evacuated 2,800 residents from nearby neighbourhoods. Seven workers were killed and 42 injured. The total cost arising from the Norco blast is estimated at US$706m, comprising US$490m to replace the cracker and US$216m in liability claims. Shell is believed to be fully insured for the event.

Piper Alpha Explosion
Occidental, 6 July 1988

At 9.45 pm on the day of the explosion one of two condensate injection pumps failed on the Piper Alpha
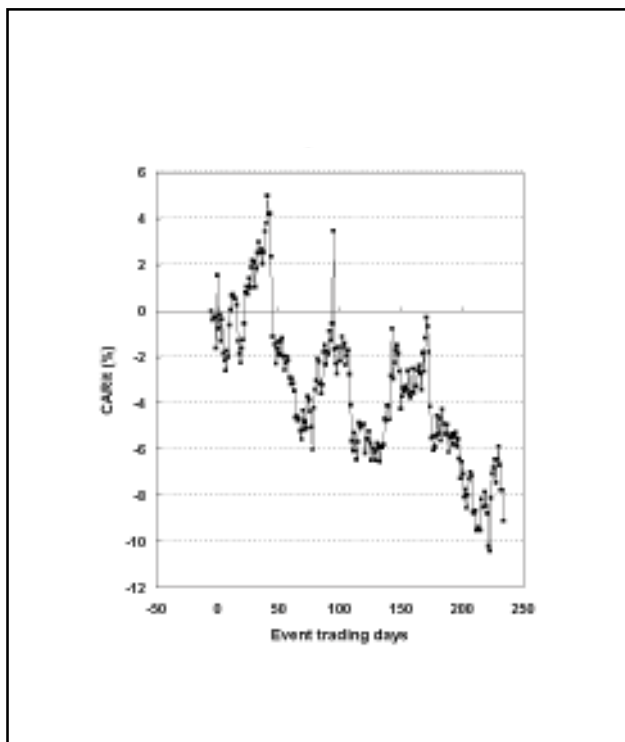

oil platform in the North Sea, 120 miles east of Wick, north east Scotland. The other pump had been shut down for maintenance and, unaware of its condition, workers are assumed to have restarted it. This resulted in a leak of condensate, creating a small explosion which knocked out safety equipment, and a series of major blasts caused a fireball. At 10.20 pm, the gas pipeline riser fractured, leading to a massive explosion and the collapse of the drilling derrick. 167 workers died. The bodies of 31 were never recovered. Only 63 people survived. The principal cause of death was smoke inhalation and a few died of burns. The total financial cost of the disaster is estimated at US$1,400m.

Lockerbie Air Crash
Pan Am, 21 December 1988

A terrorist bomb exploded aboard Pan Am Boeing 747 Flight 103 causing the aircraft to crash. The bomb exploded over the Scottish market town of Lockerbie, about 55 minutes after taking off from Heathrow. 270 people were killed; all 243 passengers and 16 crew on board, and 11 people on the ground. On 21 December 1993, investigations revealed that the bombing was ordered by Iran and the bomb was planted by Libya with the connivance of Syria. Relatives of those killed in the crash have filed suit against Pan Am. A few lawsuits have been settled but many remain active. Following the verdict against Pan Am of "wilful misconduct", United States Aviation Insurance Group (USAIG) revised its original estimate of liability claims from US$250m to US$470m in total (21 February 1994). The hull of the aircraft was insured for US$32m. On 21 December 1989, Pan Am estimated that it had suffered a revenue shortfall of US$150m in lost bookings as a result of the disaster, bringing the estimated total cost to US$652m.
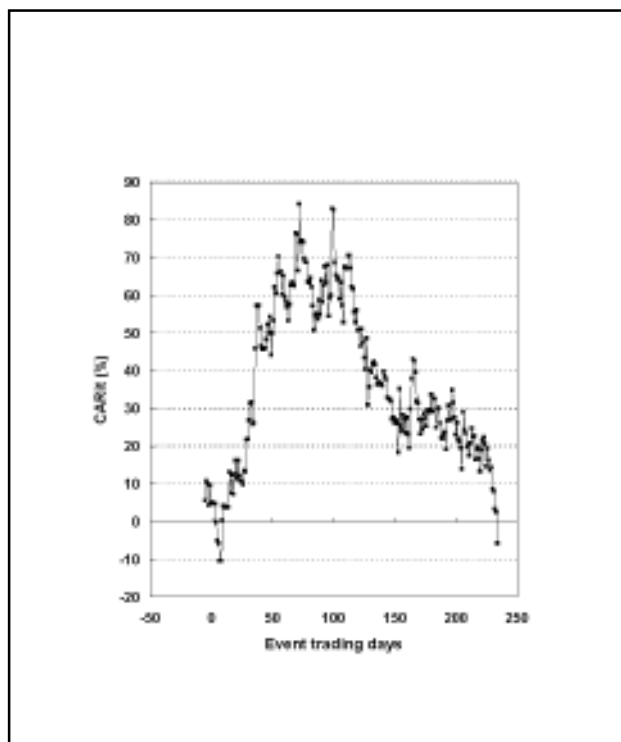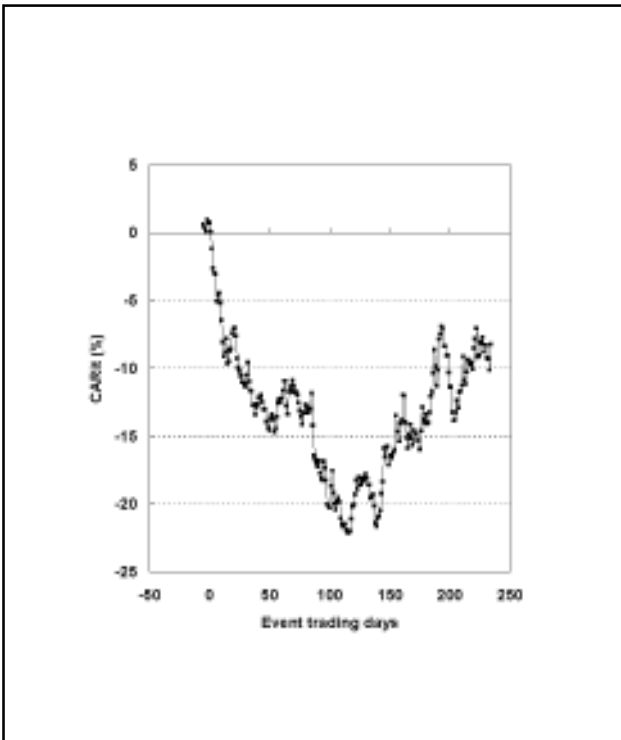

Alaskan Pollution
Exxon, 24 March 1989

The fully loaded United States supertanker Exxon Valdez, ran aground in the Gulf of Alaska. It was manoeuvering through heavy ice when it ran into Bligh Reef, puncturing 8 of its 13 cargo tanks and spilling 11m gallons of crude oil into Prince William Sound. 1,500 miles of pristine shoreline were polluted, more wildlife was killed than in any other industrial accident and Alaskan natives, particularly fishermen, suffered long term harm to their livelihoods and subsistence way of life. The latest estimate for the total cost of the oil spill is over US$11.5bn (7 October 1994). This figure comprises US$8.7bn in damages, US$2.5bn already paid towards the clean-up operation and US$316.5m paid to victims of the accident. It appears that the
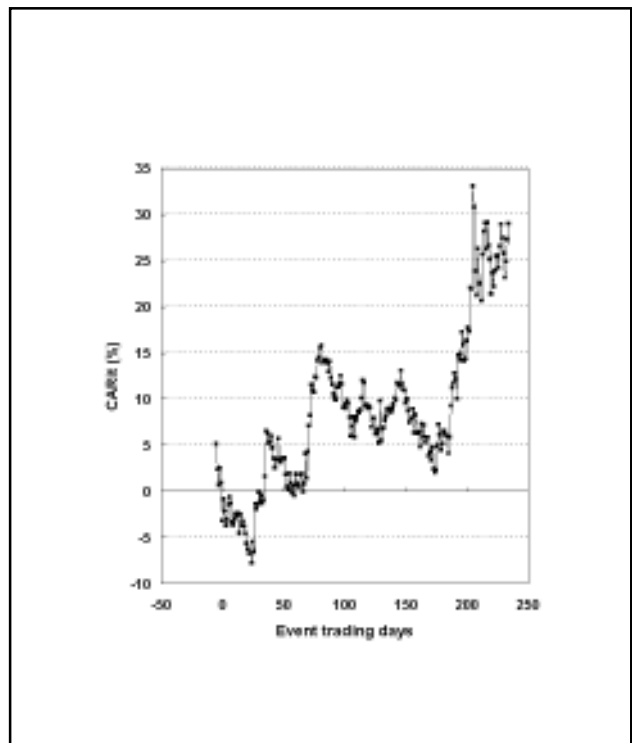
International Tanker Owners Indemnity Association provided US$400m of pollution insurance cover for the "Exxon Valdez" and reinsured about US$388m in Lloyd's and member companies of the Institute of London Underwriters (ILU).

Halcion Side-Effects
Upjohn, 19 September 1989

Adverse side-effects, including confusion, agitation, hallucinations, paranoia, amnesia and aggressive behaviour are alleged to result from taking the prescription drug, Halcion - Upjohn's brand-name for benzodiazepine hypnotic triazolam. On 3 October 1991, the FDA approved the drug, reporting that the "benefits outweighed its risks". Although Upjohn has settled some cases, the company still faces hundreds of lawsuits over the drug. Marketing of Halcion remains suspended in Britain, Norway, Argentina and Brazil. Known legal costs include those for the "Grundberg case", a US$21m claim where Upjohn settled out of court for an undisclosed amount, and US$2m for a another case.
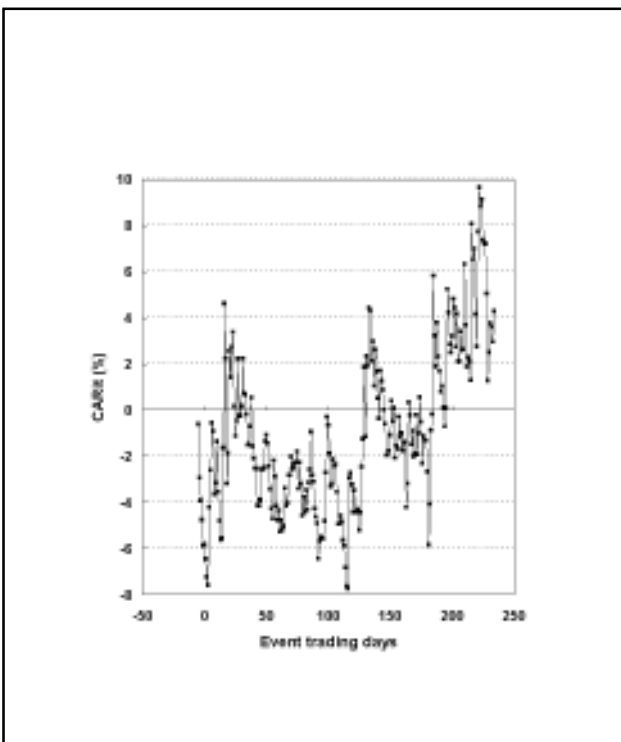
Pasadena Explosion
Phillips Petroleum, 23 October 1989


The explosion occurred after a seal on a polyethylene reactor ruptured, leaking highly inflammable ethylene and isobutane gas from a pipeline. It is unclear what ignited the gas. The fire blazed for more than eight hours before being brought under control and, with the explosion, caused extensive damage to half the petrochemical facility. 23 people were killed and 130 injured. Total costs arising from the disaster are estimated at US$1,300m.

Benzene Contamination
*Source Perrier, 10 February 1990*
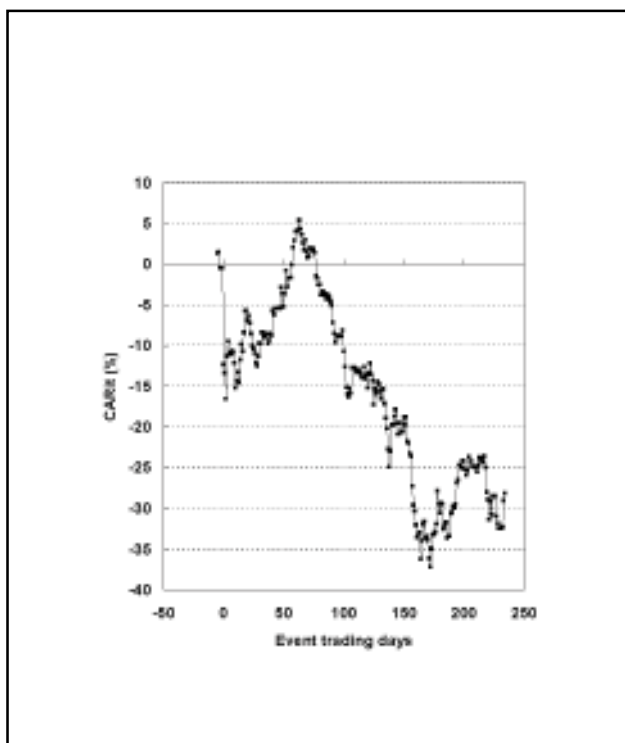
The natural gas present in the Perrier spring at Vergeze in the Gard, southern France contains a number of impurities. The carbon filters which should have removed these impurities, including cancer-inducing benzene, had become clogged. A faulty warning light on the control panel went undetected by employees for more than six months, allowing the filters to become blocked. When the mineral water was found to be contaminated by benzene, 160m bottles were recalled from 120 countries. The bottles were destroyed and replaced. Nobody suffered as a result of drinking the benzene-infected water. The Perrier group estimated that "l'incident Benzene" had cost it US$262.9m: US$197.5m for recalling and destroying the bottles, US$47.7m for related advertising communication, consultants and financial charges, and US$17.7m for associated administration charges. Perrier did not have product guarantee and recall insurance.

Prozac Side-Effects
Eli Lilly, 17 July 1990

Violent secondary effects are alleged to result from taking the prescription anti-depressant drug, Prozac - Lilly's brand-name for fluoxetine hydrochloride. On 20 September 1991, the United States federal Food and Drug Administration (FDA) advisory committee issued a favourable verdict on Prozac, finding no link between the drug and suicide. Numerous lawsuits have been filed against Lilly, alleging that Prozac has driven people to murder another, suicide and other forms of violence. None has been successful to date, although several are still pending.
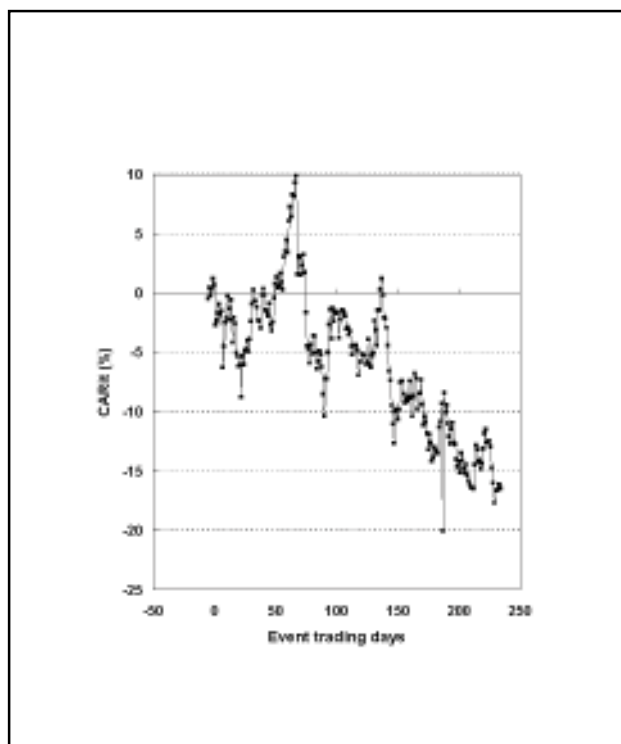
Baltic Exchange Bomb
*Commercial Union, 10 April 1992*
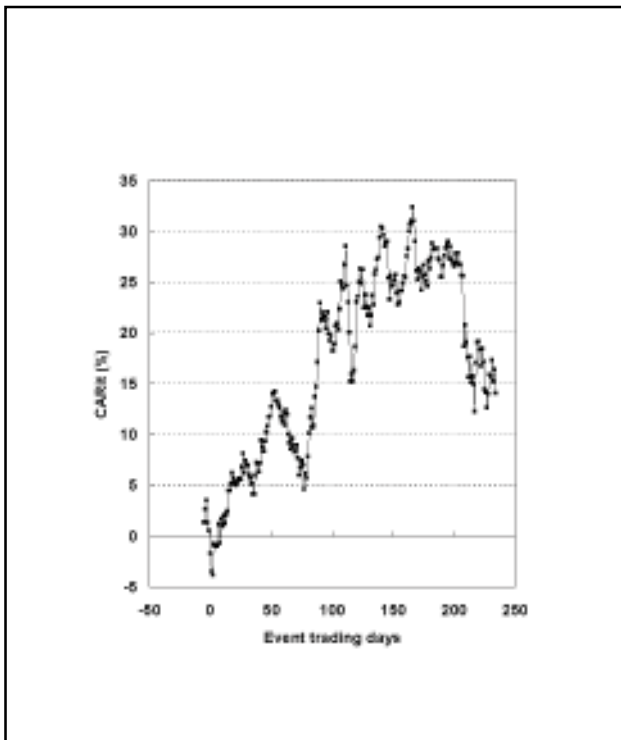
A bomb, planted by the IRA, exploded in London's financial district. The 45kg bomb was placed in a car outside the Baltic Exchange which, together with the Commercial Union (CU) tower which accommodates the company's headquarters, bore the brunt of the explosion. Hundreds of CU's computers were wrecked, 2,000 panes of glass were smashed and the tower was rendered useless for a year. Three people were killed and 91 injured. On 19 April 1992 total costs were estimated at US$2,170m, comprising US$560m rebuilding costs, US$560m business interruption claims, and US$1,050m in repairs to computer links, roads and a church.

Faulty Bottles
Heineken, 25 August 1993

Defective glass, manufactured by BSN's Vereenigde Glas, was used to make export beer bottles. When opened or transported, glass splinters could fall into the beer. Heineken recalled, destroyed and replaced 15.4 million bottles. Nobody was injured as a result of the glass splinters. At the time of occurrence, Heineken estimated the loss to be anything between $10m and $50m. It was unclear whether Heineken's product liability insurance policy would cover the losses. Coverage is unlikely, given the small market for product recall in Europe. On 14 April 1994 Vereenigde Glas agreed to compensate Heineken for an undisclosed sum.
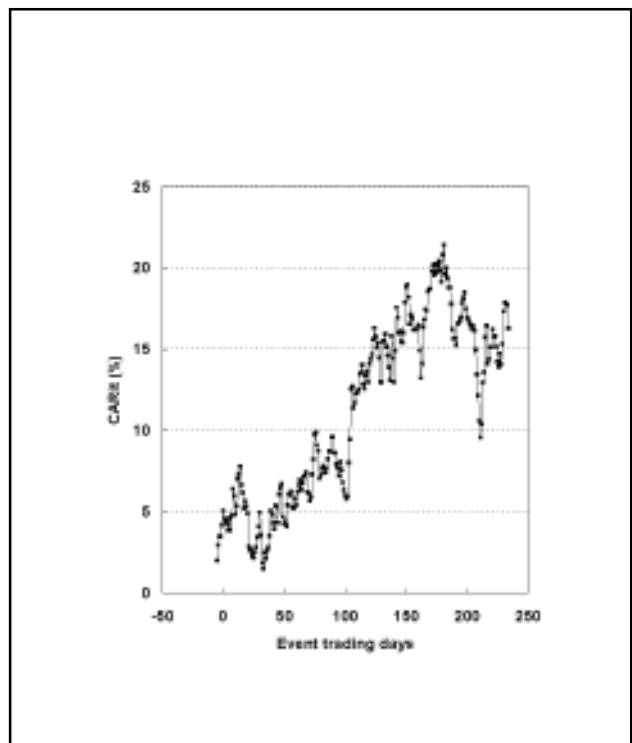
Data & Methods

In order to isolate the effect of the catastrophe on shareholder value, it is necessary to rule out the effect of other events that may impact on shareholder value simultaneously. In this study, this is accomplished in two phases. The first phase is at the individual company level and involves the filtering out of share price movements and the effects of market-wide factors. The result of this process is the estimation of so-called *abnormal returns* for a period immediately after the catastrophe. In the second phase, the abnormal returns are aligned on the catastrophe (day 0) and averaged across the total sample. These average abnormal returns are then accumulated over what is now catastrophe time, resulting in a set of portfolio returns from day 0 known as *cumulative abnormal returns* (CAR). The second phase filters out any company-specific effects not related to the catastrophe.

Figures 1 and 4 show the CARs for portfolios of the total sample and the portfolios of recoverers and non-recoverers. The CAR charts reflect the impact on shareholder value in percentage terms.

More formally , the abnormal return on share i on day t, is defined as:

$$U_{it} = R_{it} - E(R_{it})$$

where:

R_{it} = the return on share i on day t.

$R_{it} = \log(P_t / P_{t-1})$

E = the expected value operator.

P_t = share price on day t.

The expected return is modelled via a model of the form:

$$E(R_{it}) = a_i + b_i R_{mt}$$

where:

R_{mt} = the return on the market portfolio on day t.

The model parameters, a_i and b_i, represent the intercept and slope coefficient respectively, estimated from a market model regression of the following form:

$$R_{i\tau} = \alpha_i + \beta_i R_{m\tau} + \varepsilon_{i\tau}$$

The risk-adjustment procedure is based on the well-known Capital Asset Pricing Model. The systematic risk parameter, beta, is calculated for each individual company, and is equal to the slope coefficient in a time series regression of the return on stock i (R_{it}) on the return on the market portfolio (R_{mt}). In this way, the results are controlled for market-wide influences.

The abnormal returns for each firm are accumulated over the event window as follows:

$$CAR_{pt} = \frac{1}{N} \sum_{i=1}^{N} \sum_{t=0}^{t} U_{it}$$

where:

CAR_{pt} = cumulative abnormal return on portfolio p on day t, relative to the day of the catastrophe ($t = 0$).

N = the number of corporate catastrophes in portfolio p.

In addition to examining the direct impact of the catastrophe on shareholder value, figures 2 and 3 report the impact on trading volume and volatility respectively. The metric to evaluate the impact on trading volume is defined relative to the average trading volume in the share. Formally;

$$UTV_{it} = TV_{it} / ATV_i$$

where:

TV_{it} = trading volume of share i on day t.

ATV_i = 12 month average trading volume of share i, over event months -6 to 0 and 1 to 7.

UTV_{it} was calculated for each share for the first month following the event. It is assumed that whereas a corporate catastrophe may affect stock price behaviour throughout the entire post-event year, any impact on trading activity will be evident primarily in the first post-event month only.

Volatility is measured as the volatility in the daily share returns over a two year interval surrounding the catastrophe. These were then averaged across catastrophes.

Pre-event and post-event variances were calculated for each catastrophe as follows:

$$\sigma^2 = \left[\sum_{t=1}^{t} (R_{it} - R_{it-1}) \right] / n\text{-}1$$

where:

n = the number of trading days in the event window.

The raw data on share prices, trading volume and

market capitalisation underlying this study were obtained from the Datastream financial database. The data are daily and relate to trading days. The analysis is conducted relative to a common event time, rather than in calendar time. In the case of each catastrophe, abnormal returns are calculated in the local currency of the parent company, and the market index chosen varies according to the market in which the shares are traded. Since the abnormal returns on all shares are measured in real terms, their additivity across numeraires appeals to Purchasing Power Parity. Table 2 indicates the market index selected for each company.

Table 2: Choice of Market Index

Company Stock	Market Index
Johnson & Johnson	Standard & Poors Composite
Union Carbide	Standard & Poors Composite
Occidental	Standard & Poors Composite
Pan Am	Standard & Poors Composite
Exxon	Standard & Poors Composite
Upjohn	Standard & Poors Composite
Phillips Petroleum	Standard & Poors Composite
Eli Lilly	Standard & Poors Composite
P&O	FTA All Share
Shell Transport & Trading[1]	FTA All Share
Commercial Union	FTA All Share
Sandoz	SBC General
Source Perrier	SBF 250[2]
Heineken	CBS All Share General

Data on trading volume were unavailable for Sandoz and Perrier. Consequently, the catastrophe portfolio comprises 13 catastrophes where trading volume is analysed. On days where there was no trading, the data points were removed from the analysis and the average figures were adjusted accordingly.

All other data were obtained from the annual reports and accounts of the portfolio companies, and from Reuters Textline, the international newspaper and newswire archive.

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1 The financial and operating results of Shell Oil Inc are integrated into the consolidated accounts of Royal Dutch Petroleum Company and The Shell Transport and Trading Company plc (henceforth "Shell"), where the former owns 60% of the Group concern and Shell owns the remaining 40%. As expected, the share price behaviour of Royal Dutch and Shell were found to be highly correlated; $R^2 = 0.995$. Consequently, for ease of data access, Shell share prices and trading volume were chosen to represent Shell Oil in the analysis. Consolidated Group figures were used in calculations of market capitalisation.

2 Daily index figures for the Paris Bourse were unavailable. Consequently, weekly figures were used and it was assumed that the market index did not fluctuate during the week.

The Authors

Rory F Knight,
MA (Oxon), MCom, PhD, CA
Dean and Fellow in Finance,
Templeton College

Deborah J Pretty
BA (Hons), AIRM, ARM
Doctoral Research Student
Christ Church

Dr Knight has extensive experience of working in the financial sector. He has also held chairs in the University of Cape Town and in the International Management Institute, Geneva (now IMD). Immediately before coming to Oxford he was the Deputy Director of the Centre for Advanced Studies, a foundation within the Swiss National Bank (the central bank of Switzerland) - an institute with which he retains an active association. He is a visiting professor at a number of universities around the world including Ecole Nationale des Ponts et Chaussées (Paris), INSEAD (Paris), EOI (Madrid), the Australian Management School and the University of Cape Town. Dr Knight is also programme director of the Oxford Advanced Management Programme.

His special interests include: Corporate and Financial Strategy; International Investments and Corporate Finance; Currency Risk Management; Joint Ventures; Mergers and Acquisitions; Corporate Ownership and Governance; International Capital and Exchange Markets.

Deborah Pretty took her first degree in Industrial Economics and is now working in the field of risk finance. Her previous experience includes risk management consultancy on risk retention strategies and alternative risk finance; writing and editing risk-related articles for professional and trade journals; and involvement in corporate strategic planning, marketing; and risk management education and training. Immediately before beginning her doctorate, she was Project Manager with Sedgwick Energy & Marine Limited (risk advisers and insurance brokers) who are sponsoring her research. Previously, she was a risk finance analyst with Tillinghast (actuarial consultants).

Her special interests include: Corporate Risk Management Strategy; Economics of Insurance; Alternative Risk Transfer (ART) Techniques; Strategic Planning; Risk Perception and Analysis; Crisis Management; Financial Modelling.