Black Swan Events – Should you be concerned?

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The discovery of black swans in Western Australia was a shock for scientists. Today those unexpected birds have become a symbol for the disruption of the bell curve that is used for most forms of variation. Bhopal, Exxon Valdez and Société Générale have shown that, in business, the highly improbable can occur, with devastating consequences. In this article the authors take a closer look at some of these incidents, examine the effect on companies and show what you can do to prevent a Black Swan event happening to you.

Black Swan events have entered the jargon following the success of Nassim Nicholas Taleb's book 'The Black Swan: The Impact of the Highly Improbable'. Taleb writes about very low-probability / very high-impact events with three characteristics:

1. They lie outside the realm of regular expectations. In statistical terms these events are not in the main body of the bell curve used to account for many common forms of variation. Black Swan events are outliers in the tails of the distribution and interestingly these tails are often "fat" because there are more events than expected in the extremes.

2. A Black Swan event carries an extreme impact. One of Taleb's contentions is that nothing in the past can convincingly point to the possibility of such events.

3. In spite of its unforeseen character, human nature makes us concoct explanations for a Black Swan occurrence after the fact, making it explainable and predictable.

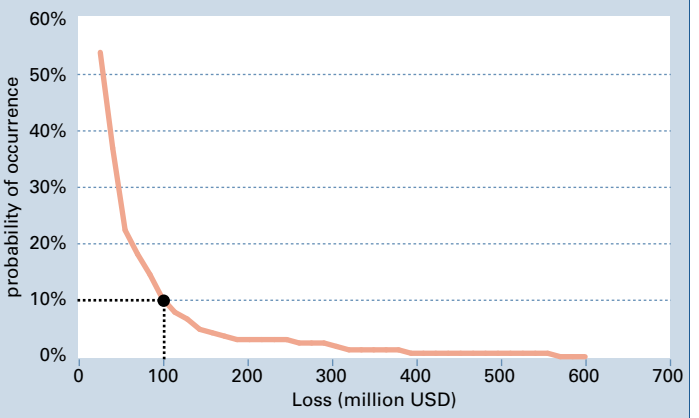
When Black Swan events occur in the context of company operations, they can put the affected company in a potentially unsustainable position, as illustrated by the position of Union Carbide following the Bhopal disaster in 1984. But if they are so rare and unpredictable, are such extreme events something for companies to be concerned about? And if so, is there anything that they can do proactively to help prevent them? In this article we review some of the consequences of Black Swan events and explore possible preventive approaches.

Fat tails and unexpected major losses

In order to explain the concept of a "fat tail", it is useful to consider the catastrophic losses resulting from accidents, such as large fires or explosions, suffered by oil and gas

companies. The corresponding loss data that insurance companies collect can be plotted to show the probability of losses of various sizes (see Table 1).

Table 1 **Loss history: losses vs. probability of occurrence**



Source: Insurance Company Loss Data, Arthur D. Little Analysis

The graph illustrates that 90 per cent of these serious events result in losses of less than $100 million. It is interesting to note that when we work with operators trying to estimate the potential size of losses, very few are willing to consider individual events with losses of this magnitude. Typically loss-ranking matrices adopted by such companies do not envisage losses greater than $10 million. But the loss history shows that not merely are the majority of such losses 10 times larger, a small proportion are larger still and are true "Black Swans".

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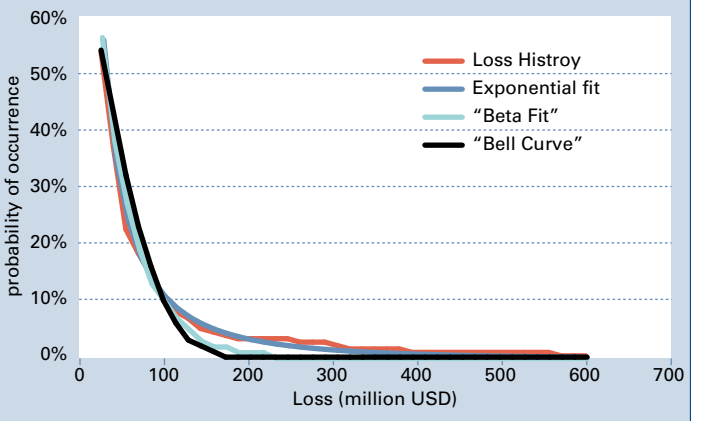
Yet these events are not as rare as one might imagine. The data in the graph include 165 major fires and explosions that occurred over a 40-year period; in other words, on average more than four such events occur in the industry each year. Of course the "on average" does not happen; the characteristic of these very large losses is that they do not occur on average and (to the consternation of insurers) often come in flurries.

In recent years there has been increasing attention paid by financial modellers to these rare extreme losses under the general description "Extreme Value Theory". Particular attention has been paid to the shapes of the tails in the loss profile. The attempts to fit the data in Table 2 illustrate the point.

Table 2 **Loss history: Fitting a curve to the "fat tail"**



Source: Insurance Company Loss Data, Arthur D. Little Analysis

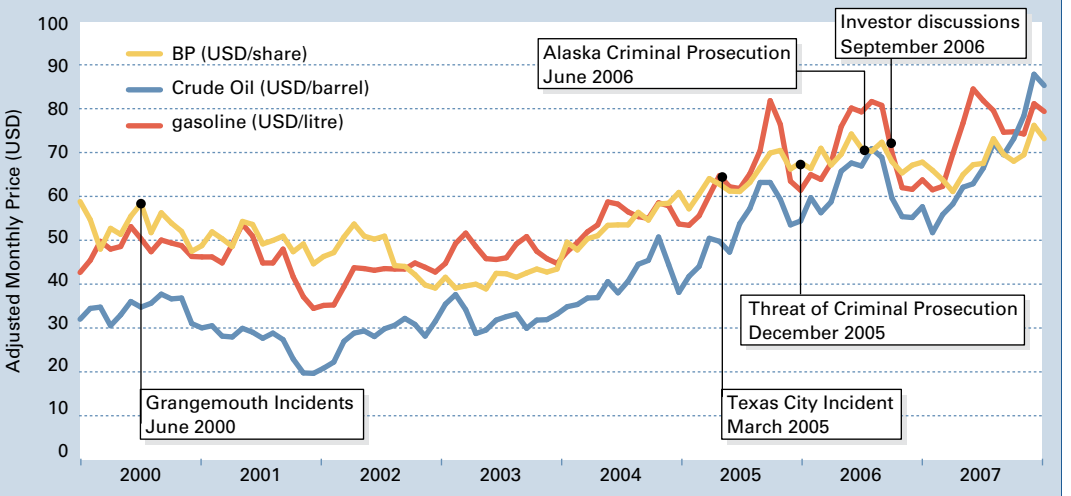
Taleb notes that, in spite of the unforeseen character of a Black Swan event, human nature makes us concoct explanations for its occurrence after the fact.

It may be seen from the loss history line that the normal distribution (the often-cited bell curve) does not fit the bill - the tail of the loss history curve clearly shows that very large losses occur with greater probability than would be expected. Skewed distributions are required to model the curve, and in this example a much better fit is achieved using an exponential distribution. This point is not just about esoteric statistics. The important message is that if companies wish to predict the scale of losses that can occur (for example by Monte Carlo simulation), appropriate "fat tail" distributions should be used for modelling.

The share price impact of a Black Swan event

The third of Taleb's three characteristics of Black Swans helps us to understand the way in which stock markets respond. Taleb notes that, in spite of the unforeseen character of a Black Swan event, human nature makes us concoct explanations for its occurrence after the fact. The good news is that this suggests that one completely unexpected loss can be accepted and confidence in the affected company can be quickly restored. The bad news is that a sequence of unexpected losses eventually does impact share price negatively because it may point to systemic shortcomings in the company's operations.

Table 3 **Loss history: losses vs. probability of occurrence**



Source: BP Investors Relations, USEIA and Arthur D. Little analysis

The history of the BP share price is a good illustration of the point (see Table 3). It can be divided into two periods, the first from 2000 to 2005, and the second after 2005.

Table 3 shows the response of the BP share price to accidents at its Grangemouth refinery in the UK and the subsequent legal proceedings. At the time of the accidents, which attracted national coverage, in June 2000 there was a decline in value of BP stock but that was matched by similar falls in other oil stocks. At the time of the court hearing 18 months later, and the imposition of a heavy fine, there was, if anything, a strengthening of the BP price relative to crude oil and gasoline prices. Despite the accident, the BP price tracked the crude oil price for several months. The pattern suggests that, for this very large company, both the accidents themselves and the court judgment and fine had a negligible impact on company valuation.

Table 3 also shows the response of the BP share price to an accident in Texas City three years later. A major catastrophic hydrocarbon release and consequent explosion at BP's Texas City Refinery led to the deaths of 15 staff and injured 180. This major incident led to a significant drop in relative share value of about 10 per cent, which persisted for about eight weeks before recovery was complete. Even the announcement of a fine of $21.4 million in Septem-

ber 2005 appeared to have no depressing effect on the share price. Indeed the reaction was somewhat similar to that noted at Grangemouth, where defining the penalty seemed to lift the market. (In both cases the level of the penalty was dwarfed by the cash flow generated by the company.)

But things started to change from then onwards. When in December 2005 a criminal prosecution was announced concerning the Texas City incident, the relative share price showed a drop of up to 10 per cent, which was not fully recovered. Six months later another criminal prosecution was announced, this time concerning an oil pollution incident on the Alaska North Slope. This occurrence depressed the share price by a further 15 per cent and there was no evidence of recovery. Three months later, after persistent concerns about BP management performance, one-to-one discussions were held between major investors and the BP board. The news of these meetings depressed the relative share price by a further 20 per cent, again with no signs of recovery. The sequence contributed to the unplanned resignation of the BP chief executive in May 2007.

Recovery is possible from a Black Swan event, even though the short-term consequences can be very severe. Single catastrophic events are often "forgiven", as a result of the process Taleb calls "concocting explanations for Black Swan occurrence after the fact".

The insight to be drawn from this story is that, for such resource-rich corporations, recovery is possible from a Black Swan event, even though the short-term consequences can be very severe. Single catastrophic events are often "forgiven", as a result of the process Taleb calls "concocting explanations for Black Swan occurrence after the fact".

Punishment can be hard, however, when a sequence of events points to systemic and consequently manageable failures. The Baker Panel investigations into the Texas City disaster, released in January 2007, brought to light systematic failure in BP's safety management. This could be interpreted as an "explanation" for an event that the Texas City operators would have probably regarded as incredible prior to its occurrence. However, the critical factor was that during this period other incidents occurred, none of which was as catastrophic as that at Texas City but which were able to be painted, perhaps unfairly, as apparent corroboration of the "explanation". Where the "explanation" developed post-event to account for the Black Swan event is apparently validated by subsequent short-term incidents,

damage to market capitalisation may not be recoverable until a management change occurs.

How to prevent Black Swan events

It is perhaps all too easy to point a finger at BP, but complacency would be unwise. Whilst this is one of the more recent examples of a corporate Black Swan event, others have already taken place since and will continue to occur in the future – there are not many who would have predicted the losses at Bear Stearns in the US and Northern Rock in the UK, for example.

In theory, Black Swan events cannot be identified and therefore cannot be prevented. In practice, Black Swan events are typically a result of a long chain of smaller sub-events that in series lead to catastrophic experiences. If one or more of the sub-events are removed from the series, then the chain is broken. This gives us a possible means of preventive action.

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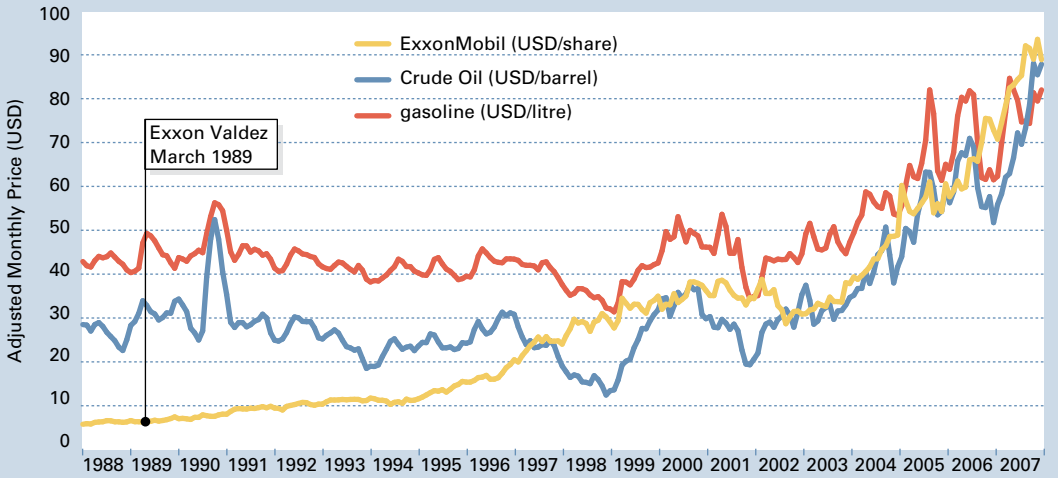
To illustrate this point, let's consider a Black Swan event experienced by Exxon. On March 24, 1989 the Exxon Valdez tanker hit a reef in Prince William Sound, Alaska, and released approximately 262,000 barrels of crude oil. Exxon spent billions of dollars remedying the release and monitoring potentially long-term impacts.

As with the BP Grangemouth experience, the Exxon stock value was little impacted (see Table 4). Unlike BP, however, Exxon and later ExxonMobil have avoided subsequent Black Swan events. Its adjusted stock consistently increased in value even during times of stagnant crude oil and retail gasoline prices during the 1990s and has tracked crude oil values since the large run-up in prices since 2002.

Table 4 **Evolution of ExxonMobil share price**



Source: ExxonMobil Investor Relations, USEIA and Arthur D. Little analysis

ExxonMobil has avoided Black Swan events for nearly 20 years. It seems hard to believe that it has just been "lucky", although of course there will, necessarily, always be a certain element of luck. It is fair to assume that the company's strong record after Exxon Valdez is largely the result of enhancing its Operational Integrity Management System (OIMS) through a nearly religious devotion to continual improvement in performance – perhaps a level of devotion that can only be achieved after suffering a catastrophic event such as Exxon Valdez.

OIMS is an 11-element safety, health, environmental and security management system. Element number 2 strongly emphasises risk identification, assessment, management and monitoring (see Table 5 next page). Ultimately, ExxonMobil believes that OIMS leads to increased reliability and to superior safety, health, environmental and security performance, thus providing a competitive advantage.

There are plenty of other examples from history that show that rigorous and robust risk identification, assessment, management and monitoring may not identify all potential Black Swan events but could well mitigate their effects. For example, it was inconceivable that the Titanic would sink in the North Atlantic on its maiden voyage after striking an iceberg. However, the chain of events that led to the unim-

Table 5 **Risk Management at ExxonMobil OIMS**

Comprehensive risk assessments can reduce safety, health, environmental and security risks and mitigate the consequences of incidents providing essential information for decision-making.

2.1	Risk is managed by identifying hazards, assessing consequences and probabilities, and evaluating and implementing prevention and mitigation measures.
2.2	Risk assessments are conducted for ongoing operations, for prjects and for products in order to identify and adress potential hazards to personnel, facilities, the public and the environment.
2.3	Periodic risk assessements are performed by qualified personnel, including expertise from outside the immediate unit, as appropriate.
2.4	Risk assessments are updated at specified intervals and as changes occur.
2.5	Assessed risks are addressed by spcified levels of management appropriate to the nature and magnitute of the risk, and decisions are clearly documented.
2.6	A follow-up process is in place to ensure that risk-management decisions are implemented.

Source: TonenGeneral

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aginable loss of life and property could possibly have been prevented or mitigated using a risk identification, assessment, management and monitoring programme. The Titanic was designed to be its own lifeboat in the event that it was sinking. We know now that the Titanic split in two pieces just before sinking, which vastly accelerated the vessel's demise. Did the Titanic's designers evaluate potential reasons why the vessel sank faster than designed and did they improve subsequent designs? A more robust expansion-joint design would not have prevented the Titanic from sinking, but it could very well have allowed the ship to fulfil its design feature of being it own lifeboat and floating for several more hours, allowing additional passengers to be rescued.

Société Générale's trading loss is a more recent example demonstrating that Black Swans can occur in all industries and that risk management principles should and can be applied to all fields. On current knowledge the Kerviel affair appears to relate to a long sequence of small events within Société Générale, where a former back-office technician circumvented trading controls and managed to establish trades for more than the value of the company. As with BP, the chain could have been broken by applying the principles

of a robust risk management system involving complete independence of the control team from the corporation. Indeed, Kerviel was from the back office, where he had acquired in-depth knowledge of the control procedures. Ongoing investigations will probably reveal the nature of the specific Black Swan event that led to the biggest trading loss in financial history.

With increasing awareness and concern of corporate responsibilities, people are less and less forgiving of those Black Swan events. The public now assumes that risk should be fully managed by corporations, which have the economic capacity to implement robust risk identification, assessment, management and monitoring throughout the company.

Application of a process safety management system

Example 1: Transport industry

Process safety management system elements can be applied to the transport industry, including highways and trains. Very similar risk identification, assessment, management and monitoring techniques as used for the oil and gas and chemical industries can also be used for transport. For example, while advising a major railroad project on the implementation of a risk management system, we helped to look at both individual risks and risk sequences that could impact the project. While many of the individual risks did not have major consequences, the approach was able to help the project identify a sequence of reasonably probable/ low-consequence risks that, if they were to combine simultaneously, would have resulted in very major delays for the project, far larger than the aggregate impact of the risks taken individually. Although the project believed that such an event could not occur, a plan was developed to monitor this chain of risks so that appropriate risk avoidance and mitigation actions could be taken if needed.

Example 2: Medical industry

Risk identification and management processes can be applied to any industry where processes can be mapped. For example, we advised a manufacturer of vaccines on major risks to business continuity, and helped identify areas where it could strengthen its current risk controls, including disaster recovery. Process safety management techniques employed included:

Potential risk identification

- Development of risk register
- Risk assessment and ranking using Monte Carlo probability assessment

Insights for the Executive

Can potential Black Swan events be prevented? The answer is a qualified yes. However, usually it is impossible to prove, since Black Swan events are by definition inconceivable and rare. The key to preventing Black Swan events is breaking the chain of sub-events that allows the inconceivable to happen. Bhopal, BP-Texas City, Exxon Valdez, the Titanic and the Hindenburg all had their own chains of events that led to the catastrophes.

The following insights can be drawn from considering the history of Black Swan events:

- Black Swan events should be considered the results of long sequences of low-impact/high-probability hazards. Although it appears that they cannot be predicted, the development and passionate application of rigorous risk identification, assessment, management and monitoring programmes across company operations can potentially remove elements of those sequences. It allows company processes to remain within design and control parameters, hopefully breaking the chain of events.

- If company operations can be set down as a detailed process flow, then process safety management (PSM) systems, including risk management, developed for the chemical and petroleum refining industry, can be used. Our experience shows us that PSM systems can be used effectively for many industries, not just oil and gas (see box text for two examples).

- A well designed risk identification, assessment, management and monitoring programme allows the company to look beyond a specific incident to understand the outcomes, not just the outputs – for example, what does the incident mean for levels of fines, protests, investor questions, licence to operate? How should we adjust risk assessments in other parts of the business? Effective risk management programmes integrate the engineer's and external affairs executive's views of the world, linking technical and stakeholder issues to ensure that outcomes are clearly recognised.

- Risk management programmes can improve your approaches to identifying and understanding potential systematic failures. For example, are there specific issues at a site level that have implications at business unit or corporate level? To what extent do risk-based management systems address issues in any asset around the world? What are company-specific key performance indicators forewarning that a Black Swan chain of events could be initiated?

You might still think that it could never happen and, indeed, the most likely outcome is that it will not. But if you take the relatively modest time and effort needed to take these precautions, catastrophic events can potentially be prevented in our very unpredictable and uncertain world.

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