Abstract

The definition of risk appetite is absolutely essential in insurance and reinsurance, where risk is the raw material. It refers to the implicit contract between the shareholders and company management, which constitutes the company’s strategy. We take risks, but we must define the exact limits of the risk to which we will be confronted when using the capital which remains the property of the shareholders.

For the reinsurance industry, the big question is whether extreme events can be predicted or not. Extreme events are uncertain and ambiguous and very complex. In particular, the most extreme events nearly always correspond to the “recorrelation” of events, otherwise totally uncorrelated or very weakly correlated. To understand “recorrelation” is therefore crucial in judging extreme events.

Reinsurers have spent a great deal of energy and effort in studying the phenomena of “recorrelation” of events which are uncorrelated during normal times and try to measure their occurrence probability. This allows them to determine the probability of an event with hyperbolic distribution, according to the probability of another event, whose distribution is also hyperbolic.

The information the industry has available on extreme events is, by definition, incomplete. Furthermore, because of fat tails, distribution laws of extreme events are themselves uncertain and any new occurrence may increase this uncertainty and change our perception of the true distribution. The industry still only has very few elements available; the estimation of their distribution is consequently subject to error. Extreme events are, in principle, either insurable or reinsurable. But the limits of insurability are difficult to define, as they are moving. We can put forward the idea according to which these limits move in favour of insurability. What was uninsurable, is insurable today. This widened insurability is partly due to the growing inter-connection between the risk market and the financial markets. The insurance and reinsurance markets are efficient for such events as they have acquired indisputable experience and skills in the subject.

Because of the potentially systemic nature of extreme events, this cover can only reach its full efficiency within a public-private partnership. This partnership must be subject to research to define the conditions for its optimum functioning, maximizing the role of the private players of the insurance industry, protecting the interests of the taxpayer, and smoothing the sometimes prohibitive costs of very large-scale catastrophes.
The most simple definition of what is an extreme event refers to the very low occurrence of these events as well as their gravity in terms of destruction, human capital or physical and financial capital.

The Lisbon earthquake, mentioned by Voltaire, is a good example. It occurred on All Saints’ Day, on 1st November 1755, i.e. 253 years ago. It was followed by a tsunami and a fire which devastated the city. Since then, there has not been a major earthquake in Lisbon. Paleoseismologists estimate the time for another such quake occurring at 1500 to 2000 years. It is for this reason that the risk of an earthquake in Lisbon was qualified as (quasi) zero, three years ago. If we want to study the distribution of earthquakes in this region of the world, we have to take an observation phase that well exceeds 250 years and even 2000 years, in order to benefit from at least two observations. Similarly, the last major meteorite fall was in Siberia, luckily in an under-populated region, at the beginning of the XX century. It is a rare extreme event, but with possibly dramatic consequences, which could, in a worst case scenario, wipe out all of humanity. The probability of a meteorite falling on Paris, and destroying the entire city, is evidently not zero, but extremely low in relative terms.

In terms of the gravity of the events, the Lisbon earthquake totally destroyed the city, killing several hundred thousand people. The Tokyo earthquake in 1923 also totally destroyed the city, causing the death or disappearance of over 140 000 persons.

Two types of extremes events: “force majeure” and man-made

But the worst scenario is the combination of several extreme events, such as when the three hurricanes Katrina, Rita and Wilma destroyed the states along the Gulf of Mexico. We can of course mention the gravity of the World Trade Center attacks both in terms of human lives affected by these events and in terms of economic destruction. It is, however, important to clearly distinguish extreme events. The terrorist attacks may cost a million or a hundred billion US dollars, have an extreme character but remain controlled. However, the failure of a nuclear power station will systematically take on extreme proportions. We therefore need to be cautious and precise in characterizing disasters, both in terms of their gravity and their continuous or discontinuous character.

In reinsurance, there is the distinction made between two types of extreme events:

- events of force majeure (“Acts of God”), namely natural catastrophes, which are not the result of human behaviour: in these instances one cannot put the blame on the public authorities for the occurrence of a catastrophe; however, they can be blamed for not having devoted sufficient resources for prevention or for rescuing the victims; this is the most common scenario in large-scale natural catastrophes; in the reinsurance sector, it is estimated that 75% of annual costs in the world can be attributed to natural catastrophes; which means that the most destructive factors in the world remain natural catastrophes, namely tsunamis, floods, hurricanes, typhoons, landslides etc.

- catastrophes which result from human action (“Man made catastrophes”): they can be the result of human error or technical or technological error such as the explosion of the AZF factory in Toulouse or the explosion of the Chernobyl power station. They can, unfortunately, be the result of “Acts of Evil”. The most recent criminal catastrophe is of course the World Trade Center attacks; only 25% of the total annual cost of catastrophes in the world is attributable to human action, whether intentional or accidental.

Nature itself is ultimately more destructive, both in terms of human life and physical and financial capital, than all the risks generated by the actions of man. One year was, however, an exception to this historic rule: the year 2001. The losses caused by “Acts of Man” were equivalent to those caused by “Acts of God”, due to the World Trade Center attacks.
Are extreme events on the rise?

As the graphs below show, the number of catastrophes with a human or natural origin seems to have seen a vast rise in the world since the end of the 1960s, as is the case for the cost of these catastrophes.

The violence of the shocks corresponding to hurricanes Katrina, Rita and Wilma as well as the World Trade Center attacks are clear in these graphs. It is evident that these series can be affected by a statistical bias. The recording of the catastrophes which arise in the world – both in terms of frequency and costs – has significantly improved throughout the last century. But even by correcting the data from this bias, the trend is so clear that it is difficult to doubt that the frequency and cost of natural catastrophes have risen considerably.

Number of catastrophes around the world

Insured costs of catastrophes (in US$bns)

One could dwell on the composition of extreme events and whether they result from “individual shocks”, from the combination of several individual “shocks” or a “serious of similar individual shocks”. In fact, major risks more often result from a series of extreme events. A single event tends to pose major problems in terms of absorption, but the sometimes insidious repetition of “extreme” or “intermediary” events is more often catastrophic as it is a lot more difficult, or even impossible, to absorb. From this point of view, pandemics are very dangerous extreme events: obviously a pandemic such as avian flu is bearable at an individual level, but if the disaster is multiplied by 10, 100 000, 1 million or even 17 million people, as was the case for Spanish flu at the end of the First World War, society is confronted with a terrible catastrophe. The same is true for hurricanes. One hurricane is bearable, but five hurricanes with a very close distance are not. The market is perfectly capable of covering an initial hurricane off the Gulf of Mexico in the United States. It would be under pressure to face a second or third hurricane. And it would be testing its limits if the frequency were to explode and if, at the same, time, other different but large-scale natural catastrophes were to occur, such as floods or earthquakes. Similarly, a controlled terrorist attack can certainly constitute a very serious event, but what is really catastrophic is a wave of terrorist attacks.
However, to date, the most serious extreme events compensated by reinsurers over the last fifty years have been a lot less symbolic than hurricanes, terrorist attacks or global pandemics (and have, to a large extent, gone unnoticed by the media). Thus, the asbestos tragedy will probably be one of the most serious catastrophes compensated by insurers and reinsurers. This catastrophe combines a large number of victims and a high compensation unit cost, and takes place over several decades and in many countries. Its total cost is extremely high for the insurance industry, in particular for reinsurers who cover acute risks. Generally speaking, insurance for work-related accidents (“Workers’ compensation”) which calls into question the responsibility of employers towards their employees, has been the source of the most serious extreme events in the United States. It is worth pointing out that this type of event is not always the result of an exogenous shock or even a sudden change in legislation, as one might be led to believe, but of insidious changes in jurisprudence. In fact, changes in jurisprudence are likely to have catastrophic consequences insofar as, unlike for changes in legislation, they have retroactive effects and reinterpret contracts underway to modify the substance, suddenly multiplying the number of cases or the amount of compensation for damages suffered by a thousand, which is reflected in the balance sheets, the profits and the tariffs of insurers and reinsurers. It is in this way that questions of responsibility have been a very important source of catastrophic developments, in the true sense, during the last twenty-five years, not only in terms of work-related accidents but also in terms of medical responsibility, environmental or societal responsibility etc. And, these accidents, which have an exorbitant cumulated cost, end up going unnoticed by the general public, to a large extent, although in reality they correspond to “extreme events” which ultimately have an overall cost in human and economic terms that is greater than major natural catastrophes.

Can extreme events be predicted?

The difficulty in predicting extreme events not only lies in their intrinsic uncertainty, that is in the great volatility of these phenomena, whose probability distribution can tend towards a binomial law (either nothing happens with a very high probability, or a terrible catastrophe takes place with a microscopic probability), but above all in their ambiguity, that is the uncertainty of their true law of statistical distribution. These events belong to what is called the “distribution tail”, which means that there are very few observations to characterize their probability distribution. It can be deduced from the central distribution of similar and more frequent events, for which there are a sufficient number of observations, but a simulated model will never really reflect reality. In fact, any new observation can raise questions on the real nature of the underlying distribution and very considerably modify that which should be retained to evaluate, price and cover the risk.

More and more frequently, experts have to determine whether or not a new given event signals a new probability distribution, supposing a change in the average or in the standard deviation for example, or if it belongs to the previous distribution as estimated, which sometimes simply confirms the statistics established. Ambiguity is intrinsic to extreme events, simply because they are so rare and as only a few observations can be made: the question of the ambiguity of the underlying distribution cannot be easily raised.

The distribution of extreme events is by nature abnormal, in the sense that it does not correspond to a Gaussian distribution, which systematically underestimates the probability of their occurrence. This is true for real phenomena (hurricanes) and for financial phenomena (very strong fall in share prices etc.). This is the phenomenon of “Fat Tail” distribution which is characterized by the fact that if the heart of the distribution is normal, the extremes are hyperbolic.
For a reinsurer, the world is therefore not “normal”, but hyperbolic, it is not continuous, but bi-varied or “diracian”. It is probably this non-linearity, this non-continuity of extreme events that poses the most problems.

Extreme events are not only uncertain and ambiguous, they are also very complex. In particular, the most extreme events nearly always correspond to the “recorrelation” of events, otherwise totally uncorrelated or very weakly correlated. In the case of extreme events, all correlations observed at a low frequency are no longer valid. The systemic risk thus corresponds to a “recorrelation” of behaviours.

Confronted with a financial crisis, all behaviours become correlated and economic players all act in the same direction. The process is suddenly no longer linear, the “decorrelation” no longer exists and a “recorrelation” of behaviours can be observed. This explains irrational behaviours, accidents, panic movements, crowd movements etc. To function properly, the market assumes very varied behaviours, very diverse anticipations and atomized decisions. It stops functioning correctly when all the players become sellers (crash) or when all the players become buyers (bubble).

The phenomenon of major catastrophes also has a particular dimension as it has a chain effect: thus, a terrorist attack of a historic scale will affect the financial markets, causing them to drop sharply, it will affect economic growth, which will slow, and industrial sectors which will suffer and so on.

The World Trade Center case is symbolic here. Under normal circumstances, terrorist attacks have very little effect on the financial markets. In the case of the World Trade Center, the shock was of such magnitude that there was a “recorrelation” with the financial markets on the very same day.

At the same time, reinsurers saw a significant rise in their liabilities, corresponding to the estimated cost of the catastrophe and a 20% fall in equity prices, leading to a significant reduction in their assets. On this occasion there was therefore a “recorrelation” between the financial markets and the terrorist attacks. This type of “recorrelation” is crucial in understanding extreme events. This is why reinsurers have spent a great deal of energy and effort in studying phenomena of “recorrelation” of events which are normally uncorrelated and try to measure the occurrence probability. To this end they use the so-called “copula” technique. This allows them to determine the probability of an event with hyperbolic distribution, according to the probability of another event, whose distribution is also hyperbolic. It is based on the hypothesis of a hierarchical dependence between the two events, at least in extreme situations. Yet, it does not require a formal causality between them, as the uncorrelated phenomena, under normal circumstances, have barely any evident links of causality.

Today, the copulas are amongst insurers’ and reinsurers’ most sophisticated internal models. In this respect, different techniques are used. However, a reinsurer prefers correlations founded on the hierarchical copula of Clayton to that of Gumbel, to Student’s T-distribution and to Rank’s correlation. The graph below shows that Clayton reproduces better than the other formulas the low correlation of the events concerned in normal circumstances, with their “recorrelation” in extreme situations (the X and Y axes of the graphs below correspond to the respective distribution of each of the two events). It can be noted to what extent the advantages of diversification can be non-linear.
Are extreme events insurable?

The market is theoretically always in a position to propose solutions. But, the question is not in knowing whether the supply exists, but whether the curves of supply and demand meet in the region where the quantities and prices are positive. In terms of the supply, the market naturally has difficulties in pricing this type of risk due to its "ambiguity". The providers seek to cover themselves not only against the uncertainty but also against the "ambiguity" of the phenomenon, i.e. against the risk of discovering ex post that its distribution law is significantly less favourable than it was thought ex ante, on the basis of known observations.

The economy thus demonstrates that the providers, in this instance the insurers and reinsurers, must request not only a risk premium, but also an ambiguity premium to cover this type of risk. Conversely, in terms of the demand, the market tends to observe inefficient behaviours of risk aversion, which systematically underestimate rare and distant threats. Daniel Kahneman was awarded the Nobel prize for economics for his work on this subject. It is easy for a person to have a relevant subjective perception of the risk of a car accident but it is a lot more difficult for him to have a correct perception of risks that are more distant and more difficult to materialize such as avian flu, a phenomenon whose development and spread is like an "avalanche", with extremely complex modelling.

The evaluation, anticipation and even the rational analysis of extreme events therefore pose major problems which make the appearance of a spontaneous equilibrium on the market more delicate. The markets also have difficulty in finding sufficient capacity to cover such events. First of all, capital exposed can be significant. Thus, the direct cost of the World Trade Center reached 100 billion US dollars, whilst the catastrophe only lasted fifteen minutes. An earthquake also has a high cost even though it is over in a few minutes. Katrina, Rita and Wilma represented a total of only three days, although their cost exceeded 65 billion US dollars.

Furthermore, all extreme events are not insurable. Systemic risks, those which affect all of the system (humanity, the national or global economy, the global financial system etc.) are not insurable because there does not exist, by definition, an economic player belonging to the system, which can constitute a credible counterparty to cover this risk. Although conceptually clear, the boundary between insurable extreme events and non-insurable systemic risks remains blurred in practice. Despite the non-linearity of the world, everything is insurable to a certain extent. Between the risk which can be absorbed and the systemic risk which cannot be covered, the limits are not clearly defined, a phenomenon which can be observed in the financial sector, particularly in the case of terrorist attacks. It is also the reason behind the fact that reinsurance industry excludes the risk of war from insurance and reinsurance contracts.

Finally, the difficulty in covering extreme events is also due to the rarity of investors with low or zero risk aversion. Few investors accept buying cat bonds due to the risks covered: they could lose all their capital in the event of a catastrophe. It is for this reason that the market is (somewhat) unbalanced.

Although delicate, the coverage of extreme risks by the market is efficient, however. The insurance and reinsurance industries have covered the World Trade Center attacks, Katrina and recent earthquakes. The markets are very efficient as long as the losses are in proportion to the capacities available. Insurers and reinsurers have coverage techniques for extreme events, which combine risk pooling, through their concentration on the diversified insurance and reinsurance players, with the fragmentation of them within pools or securitization. The majority of reinsurance contracts are syndicated. And the reinsurers themselves are reinsured by retrocessionaires. It is this technique of “pulverization” of risks that is at the heart of the business of insurance and reinsurance and which provides the capacity to cover major risks that no player can ensure alone.
What is the role of the market and the state?

Although the market is in a position to satisfy the coverage needs, the fact remains that certain extreme exceptional events require state intervention. A terrorist attack on the scale of the World Trade Center attacks, especially if it is repeated, cannot be covered by the market, which does not have the necessary financial capacity. This is also the case for nuclear attacks. The state should intervene to complete the insufficient capacity of the market, but also to benefit the latter from its significant inter-temporal pooling capacity thanks to its loan possibilities guaranteed by taxes. That is why it plays a significant role in the coverage of very large-scale natural catastrophes and terrorist attacks. Of course in the event of armed conflict, the coverage of losses is always based on state intervention.

The optimum coverage of extreme events must therefore often be based on a public-private partnership as the most extreme events can only be covered by what is called public “stop losses”, an exceptional excess of loss coverage. At a certain point, the market’s coverage capacities no longer suffice and therefore require a public “stop loss”. This rule applies to armed conflicts as well as to major terrorist and systemic risks which are the exclusive responsibility of the states. This is also the case for potential losses exceeding the market’s capacities.

It would be preferable for state intervention to meet pre-defined rules rather than discretionary measures, which certainly have the advantage of being able to adapt to circumstances, but which are uncertain, difficult to decide politically and are taken precipitously without thought for the considerable moral hazard they are causing. In other words, in the event of a terrorist attack, it is preferable to know the method of intervention of the state and consequently the way in which the public powers will limit the moral hazard. This avoids the same questions having to be asked: are they going to intervene? And if yes, in what way? Will they intervene in favour of all the system or just certain banks or insurance companies? Will they intervene quickly? This is particularly important in reinsurance and should be a priority for the future.

What is important is that major events do not all arise at the same time. Covering an earthquake or a hurricane is not a problem on condition that it is not followed by a hurricane or floods the following quarter. As we have seen, the problem is not in the extreme character of these events, but in their occurrence at the same time or at very close intervals.

Insurers and reinsurers therefore fragment and disperse the risks, they pulverize them. In any case, the new IFRS rules, whilst they allow the geographic distribution of costs, make the distribution of the “costs” of major events difficult over time. Besides, it is one of the faults of the IFRS standards, the foundations and the conception of which are problematic. In addition, they are not suited to a sector where loss charges cover 500 years but in which there is a daily evaluation of the volume of its liabilities. It is completely illogical.
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