



**NANYANG  
TECHNOLOGICAL  
UNIVERSITY**  
**SINGAPORE**

Institute of Catastrophe  
Risk Management

# The Insurability of Terrorism Risk

**Gordon Woo**

ICRM Topical Report 2013-001  
August 2013

Contact Us:  
Executive Director, ICRM  
([ExecDir-ICRM@ntu.edu.sg](mailto:ExecDir-ICRM@ntu.edu.sg))  
N1-B1b-07, 50 Nanyang Avenue,  
Singapore 639798



**Know the Risk. Be Prepared.**

# 1. INTRODUCTION

Terrorism risk is perceived by many in the insurance industry to be fundamentally different from other risks, making it essentially uninsurable by the private insurance market, and requiring some degree of government intervention. To fuel this debate, one prominent insurance textbook published after 9/11 (Vaughan and Vaughan, 2003) identified four ideal elements of an insurable risk:

- (1) A sufficiently large number of insureds to make losses reasonably predictable;
- (2) Losses must be definite and measurable;
- (3) Losses must be fortuitous or accidental;
- (4) Losses must not be catastrophic (i.e., it must be unlikely to produce losses to a large percentage of the risks at the same time).

In practice, ideal insurable risks by this particular definition hardly exist. Even life insurance is subject to catastrophic losses from infectious disease pandemics. Consider car insurance, as a very common household insurance example, where sophisticated predictive analytics models have been developed to refine underwriting so as to reduce loss ratios substantially.

(1) Even with a large number of insureds, the vagaries of dangerous driving weather may erode the predictability of loss experience; (2) Third party liability losses from auto accidents may inflate claims beyond expectation; (3) Some car crashes are deliberately staged by criminal gangs to extort claims payments from insurers; (4) Auto losses in Northeastern USA from Hurricane Sandy in 2012 were on a catastrophe scale of about \$3 billion.

Clearly, the entire catastrophe insurance market, by definition, violates the fourth of these criteria. Whether for natural or man-made catastrophe risks, questions have often been raised after major losses as to the insurability of catastrophe risks. What is clear is that past experience alone is a poor guide to catastrophe insurance underwriting and risk management. Catastrophes are rare events with a return period that may exceed by a large multiple the working experience of even the most seasoned underwriter. Recognizing the inadequacy of past loss experience alone, insurers need the resource of catastrophe models to guide them.

All catastrophe models are approximate, both for natural and manmade hazards. Their usefulness for the insurance market is ultimately determined by the quality of assistance they provide in making key underwriting and risk management decisions.

This report discusses some terrorism risk modelling issues relevant for the debate over the insurability of terrorism risk. These are listed as follows:

- Counter-terrorism control  
*This is the essential basis upon which terrorism frequency can be modelled in countries where events are rare.*
- Human behaviour  
*Social networks provide the key to understanding why uncertain human behaviour is not a major hurdle in terrorism threat modelling.*
- The role of chance  
*Certain losses are uninsurable, but terrorist losses are always uncertain.*
- The diversifiability of terrorism risk  
*The geographical concentration of terrorist threats in major urban areas promotes adverse selection.*
- A comparison of terrorism and natural hazards  
*A benchmark against natural hazards is instructive to put terrorism risk modelling into catastrophe modelling context.*
- Surprise and Black Swans  
*Sustained counter-terrorism pressure mitigates the risk of future surprise attacks.*
- Commentary on statements on terrorism risk modelling  
*Responses are given to some published statements about terrorism risk modelling.*

## **2. COUNTER-TERRORISM CONTROL**

Terrorism is a manifestation of political violence aimed to coerce a nation state to make some change to its government policy. As when faced with any criminal activity, the response of the government of a nation state will be to summon its resources of intelligence and law enforcement to carry out its official duty to preserve law and order. However, there are various political situations where the task of gaining control over terrorist activity may be beyond the capability of a nation state.

First, terrorism may be the spearhead of violent anti-government protest having such widespread popular support that its military suppression may lead to an effective state of civil war. This is the situation that has developed in Syria, with the Arab Spring initiative to depose President Assad. Secondly, terrorism may have the mass support of a large ethnic community, whose basic civil rights are gravely infringed or denied. This is the situation in northern Nigeria, where Boko Haram has been committing acts of terror in the name of the local Muslim majority. Thirdly, terrorists may be allowed free rein to commit acts of violence, because it has the implicit support of the national intelligence service. This is the situation which has long prevailed in Pakistan, a country teeming with political unrest, where the national security service, ISI, has a history of supporting Islamist militants in Kashmir, and has consequently forged very close ties with Jihadi groups. In a state, where counter-terrorism forces are inadequate in strength, ill-trained or inept in capability, compromised or corrupt, terrorists may be able to attack more or less at will, and also find refuge, as did Osama bin Laden successively in Sudan, Afghanistan and Pakistan.

In all these political situations, terrorism is beyond the control of national security services. As a consequence, the frequency of terrorist attacks is not measured in the number of events per year, but rather in the number of events per month, week, or even day. Civil war is not an insurable risk, because the level of destruction that might be wrought could devastate entire towns, as has happened in Iraq and Syria. Even if an official or de facto state of civil war has not yet been attained, where the security services are unable or unwilling to exert control over terrorists, then their acts of terrorism may only be insurable for specific risks having surveyed high security, such as ample stand-off distance from vehicle bombing, and a large detachment of armed guards.

A key quantitative measure of the control over terrorism is the ratio of interdicted plots to successful plots. In countries exerting effective control over terrorism, such as the western alliance, it is just the occasional plot that evades the forces of counter-terrorism. By contrast, where terrorism is out of control, the ratio is much worse. Key to a high interdiction plot ratio is that there should be limited support for terrorism in the country. But where sectarian violence is rife, this may be far from the case. Security services then face an uphill battle to find assistance from within the supportive community to identify and convict terrorists. Northern Nigeria is a prime example of a region where the security services are struggling to apprehend Boko Haram terrorists. Local Muslim support for Boko Haram is sufficiently entrenched for coercive threats to be made to elicit information from suspects about impending plots.

## **3. HUMAN BEHAVIOUR**

In the weeks after 9/11, when insurers were facing the unprecedented mountain of claims emanating from this Al Qaeda terrorist attack, it seemed that the depths of malevolent human behaviour might be so extreme as to defy attempts at quantifying the associated risk. This has remained a common industry perspective ever since. Nobody can see inside the head of a human being, and terrorists are mostly unavailable for interview, so how can a terrorist's behaviour be forecast? The answer is that it is thankfully not necessary to forecast terrorist behaviour; it is sufficient to keep a terrorist network under extensive surveillance. By scanning a network of terrorists and their associates and sympathisers, through the judicious use of informants and communications intercepts, the great majority of plots can be foiled before a terrorist moves towards his target.

According to his book of memoirs, Decision Points, President Bush went to bed on 12th September 2001 thankful to God that there had not been a further attack that first day after 9/11. In the immediate aftermath of 9/11, the frequency of terrorist attacks was unknown. The tempo might have been one per day, per week, per month, per year. As it was, even if the CIA and FBI had let slip terrorist suspects who ultimately had a

significant part in the 9/11 operation, their preparedness and counter-terrorism capability were escalated rapidly after 9/11.

Whatever the behaviour of terrorists, it is the responsibility of a counter-terrorism organization to maintain vigilance to detect plots as they form, and to break up plots before terrorists are ready to strike. Intelligence officers cannot read people's minds, but they can track people's communications and online activities, albeit at the societal cost of some infringement of civil liberties. The mass surveillance revelations of the ex-CIA whistle-blower Edward Snowden come as no surprise to those who have analysed the process by which the security services of the western alliance have managed successfully to control terrorism since 9/11.

No person lives in complete isolation; every human being has his or her own social network. Social networks are amenable to a substantial degree of analytical characterization, providing a sufficient window on terrorist cell contacts for many plots to be foiled. The various links between members of a social network provide key insight into the involvement of an individual in a terrorist plot. The singular achievement of the western security services in interdicting 90% of significant plots since 9/11 is evidence of their command of communications networks.

Even if no bilateral communications are actually accessed, the very fact that someone is in communication with a known or suspected terrorist may draw intelligence attention upon that individual. In his Abbottabad hideout, Osama bin Laden maintained a solitary external contact outside his compound, namely with his courier. The diligent Pakistani courier evaded identification for a very long time. His day of reckoning arrived, however, when he came under scrutiny after he unwittingly received a call from a Middle Eastern friend who happened to be subject to CIA surveillance.

In countries of the western alliance, terrorists are a small minority of a modest segment of the general population bearing a strong political grievance. Many may seek to join public demonstrations to vent their anger, but few would be prepared to cross the red line from legal vociferous demonstration to the commitment of illegal acts of violence. There has been academic debate over the relation between radicalization and terrorism (Neumann, 2013). In particular, some have argued that, since only a small proportion of those radicalized turn to terrorism, attention should be focused much more intensively on how people become terrorists, rather than how they become radicalized. But, as Neumann has commented, any explanation of political violence that aims to reconstruct action pathways but fails to examine the political and social context is bound to remain shallow.

The veteran RAND terrorism analyst, Brian Jenkins, has described terrorism as 'the thin crust atop a very deep pie'. The depth of this pie matters. From a terrorism risk analyst's perspective, understanding radicalization is crucial for gauging the difficulty with which terrorists are identified before they move towards their targets. The deeper the pie of the radicalized, the harder it is to locate the terrorists amidst their midst, and to interdict plots. If only it were reasonably possible and practical to profile terrorists, then they might be picked out from the community pie of the radicalized, however large this pie might be.

Alas, profiling is ineffective. The profiling of a population to identify potential terrorists is a challenge beyond the capability of psychological science. Two brothers with very similar backgrounds may choose very different paths to political fulfilment: one peaceful, the other violent. If counter-terrorism was reliant on differentiating between suspects on the basis of their political background or behaviour, it would be a thankless, frustrating and unproductive activity. Rather than trying to second guess their political mindset, more productive for security services is the practical task of establishing their social links. The brother with the more mild temperament of the two may turn out to have terrorist social links. It is the social network which offers the best clues on terrorist activity – but this of course breaks down for the lone terrorist.

### **The Lone Wolf**

Individual terrorists, acting alone, with little interaction with others, have a minimal social network profile, and hence have the highest chance of evading detection by counter-terrorism forces. The trade-off in not involving others is that the plot would have to be tactically less ambitious and logistically less burdensome than it might otherwise be. In general, the plots perpetrated by lone wolves border on common criminality. They involve shootings with handguns, shotguns or assault rifles; grenade attacks, stabbings and mail bombings. The main

loss outcome is the spread of fear throughout the population affected, rather than any significant physical loss, insured or otherwise. The Unabomber is the epitome of the intelligent but socially introverted lone wolf.

In some instances, a lone wolf may blend in with his environment sufficiently well that the evolution of his plot may pass almost unnoticed by his neighbours and acquaintances. The Norwegian right-wing anti-Islam extremist, Anders Breivik, was the epitome of this type of local lone wolf. He had a farm for use as a safe haven for developing his fertiliser bomb, which he deployed against government offices in Oslo. Breivik's farmer neighbours had observed his patent lack of horticultural skill and experience. Despite their suspicions, they did not draw the attention of the police to his anomalous behaviour. Right-wing extremism was not on the popular radar screen at the time, as it is now.

Anders Breivik's legacy for the insurance industry includes the practical lesson that lone wolves are not just fearmongers, they can inflict significant property loss. However, it is extremely hard to conceive of any practical weapon-target combination, available to a lone wolf, for which the insured loss resulting from a lone wolf terrorist operation would be so great as to be of uninsurable dimensions.

## 4. THE ROLE OF CHANCE

For a risk to be insurable, there has to be a substantial fortuitous or accidental aspect to any claim that may result. There cannot be certainty that a loss will result. Any act of terrorism is an illegal act of violence, and is therefore a crime. But crime in its many manifestations, threatening property, life and the environment, has long been an insurable peril. So the fact that the agent of loss is malevolent in itself is not a non-insurability criterion.

Being politically motivated, terrorism is much more focused in its targeting than general crime. Any property, wherever located, might potentially be burgled, or set on fire by an arsonist, and any individual, however lowly, might be set upon and mugged. But suppose a specific high-profile figure is targeted by a terrorist organization for assassination? Would his life and home be insurable?

Contrary to what might be imagined from media reports of terrorist outrages, the role of chance in terrorism risk is very substantial. A campaign of political violence is akin to a military campaign. An adage taught to military cadets is that no plan survives first contact with the enemy. However meticulously planned a terrorist plot may be, any operation is susceptible to the vagaries of fortune. This is exemplified by 9/11 itself. This operation was impacted by Newark airport congestion, causing flight UA93 to be delayed for forty minutes, allowing precious minutes for passengers to be alerted by cell phone to other plane hijackings. But this ill fortune for the terrorists was more than compensated by the good fortune that came the terrorists way as the amateur pilots navigated their planes to strike the twin towers and the Pentagon. Even the most experienced professional pilots would have needed some luck to have achieved these remarkable feats of piloting skill under extreme pressure. Apart from the terrorist threat itself, there is a substantial degree of randomness in the loss that results from a terrorist attack. There is no clearer illustrative example than the fall of the twin towers, which depended critically on the point of impact of the passenger jets.

For some plots, luck runs out at the last moment, at the very point of attack. The chosen weapon attack mode may malfunction, or security may be tightened unexpectedly. Indeed, the deliberate randomization of security is a recognized strategy adopted at some strategic sites to thwart terrorism plans. Because of the possibility of heightened security on any specific day, terrorists may seek an alternative opportunistic target with fixed security.

Key to understanding randomness in terrorist operations is the principle of target substitution. If two potential targets are similarly attractive, the target with inferior security would be preferred by terrorists. So even if an individual is known to be on the hit-list of a terrorist organization, through the provision of security protection, it would be very far from certain that there would be a successful attack on that individual or his or her property. There have been situations where a target of opportunity has been attacked instead of an originally designated target.

Through heightened security, iconic events such as the 2012 Olympic Games have been well protected against terrorist attack. Quite apart from the resolute response of civil authorities, public situational awareness plays an important part in civil protection. Frequent warning messages about unattended baggage would have

made it harder for the 15 April 2013 Boston bombers to have left their bombs on the streets of London, or New York. Victims of the marathon bombing might reflect ruefully on the intervention of chance that caused a target switch from the Boston July 4 celebrations. The terrorists' weapons were ready ahead of schedule, and it would have been poor tradecraft to have stored them for months.

## 5. THE DIVERSIFIABILITY OF TERRORISM RISK

In contrast with meteorological and geological hazards, which have a spatial geography essentially independent of the built environment, terrorist attacks are targeted primarily at buildings of particular iconic or commercial value or political significance. Some degree of risk sharing lies at the heart of insurance. Insurers need to be able to have a diverse book of business to ensure that losses to part of their book in any one year may be offset by good results for the rest of their book.

Although there has been some public concern about rural terrorism focused on the farming community, this is a highly implausible threat from a Jihadi perspective, given that any loss would be hard to ascribe to any specific cause, and might occur naturally anyway, e.g.. mad-cow or foot-and-mouth disease. It does not require risk modelers to suggest to farmers that terrorism insurance may not be necessary. Only a couple of months after 9/11, this case against risk sharing was clearly made: *"I have farmers in my district, they have chicken houses... Those farmers do not feel like those chicken houses and those chickens need insurance against terrorism"* (Representative Bachus, Alabama, Congressional Record, US House, November 29, 2001, H8617).

The terrorism threat has a strong gradient away from major cities. It is a basic tenet of military strategy that pressure should be maintained at critical points, and not diluted away. This scotches the heartland theory that terrorists would attack anywhere so that everyone would consider themselves a potential target. With this threat geography, which is more focused than river flood hazard, the practical scope for those highly exposed to be subsidized by others less threatened is very limited. This is a market reality that disappoints advocates of risk sharing, e.g. *"Whether the market can or cannot do this is not to me the primary concern", the risk "ought to be broadly shared. This is a case for totally socializing the risk"* (Representative Frank, Massachusetts, US House, July 27, 2005: pp. 5-6). ([link](#))

In the USA, there has been a degree of socializing the terrorism risk, in that homeland security funding has been disbursed more widely across the country than would have been optimal for terrorism risk mitigation. Furthermore, the spatial gradient of actual insurance premium rates is less steep than would be warranted by the actual threat.

## 6. A COMPARISON OF TERRORISM AND NATURAL HAZARDS

Of all the natural hazards, flood risk is most similar to terrorism risk in that human initiatives can mitigate the hazard to a considerable degree. By constructing, maintaining and improving flood defences, the prospect of water overtopping the defences and flooding insured property can be greatly diminished. Without adequate flood defences, the frequency of flooding may be so high as to make the cost of insurance unaffordable. The availability of an affordable flood home insurance programme depends on mutual agreement between government and insurance organizations on the expenditure of public finances on flood risk mitigation.

But even with government risk mitigation programmes, the flood risk for some properties might still be sufficiently high as to make risk-based insurance unaffordable. To alleviate this predicament, UK insurers and Government have agreed to develop a not-for-profit flood fund, known as Flood Re, to ensure that flood insurance remains affordable and available to homeowners at high flood risk. Flood Re will establish a fund to offer people at high flood risk affordable flood insurance at a set price. Insurers will put into the fund those high flood risk homes they feel unable to insure themselves, with the premium to cover the flood risk part of the household premium capped. To help fund this cap, all home insurers will collectively be subject to an extended cross-subsidy, between lower and higher flood risks.

Psychological studies have shown that people would be more distraught over a loss caused by terrorism than by natural hazards; nobody wants to feel personally victimized. Consistent with this, government expenditure

on counter-terrorism tends to be far higher than on dealing with natural hazards. There is thus no need for a government pact with terrorism insurers over maintaining adequate funding for counter-terrorism security. National security is a government's top priority. For UK, there is a terrorism insurance pool, known as Pool Re, where there is also some element of cross-subsidy, between lower and higher risks, to cap the premiums of the properties exposed to the highest level of terrorist threat.

Except for taking action on anthropomorphic climate change, governments are powerless at natural hazard mitigation: reducing the frequency and intensity of rainstorms, windstorms, and geological hazards such as earthquakes, tsunamis and volcanic eruptions. Traditional insurance wording referred to such events as 'Acts of God'. In a scientific age, this is just a figurative term of speech. Nevertheless, embedded within it is an enduring message of universal significance. The drivers of natural hazards are literally on a super-human scale, as indeed the hazard events are, and these drivers are absolutely way beyond any human control.

This is not so of terrorism. The causative factors of terrorism are human, and even if religious terrorist organizations may seek spiritual guidance and divine assistance, terrorists are subject to human control. In particular, unlike hurricanes and earthquakes, terrorists can be arrested or killed. It is ironical that insurers have come to be more nervous and apprehensive about insuring natural hazard 'Acts of God' of a super-human scale, than insuring manmade hazards committed by terrorists with claimed divine inspiration. The energy release in major natural catastrophes dwarfs the energy release of all actual or planned terrorist attacks except for a nuclear explosion. When Hurricane Katrina ravaged the US Gulf Coast in 2005, Jihadis rejoiced that the hurricane had joined the Jihad. Amongst the damage wrought by Hurricane Katrina, an astonishing number of oil and gas platforms in the Gulf of Mexico were wrecked. For a terrorist attack to be capable of taking out even one offshore platform would count as a major success.

Hurricane Katrina was just one of a sequence of destructive hurricanes in 2005. Hurricane Wilma subsequently caused major damage in Miami. This led to a 2007 proposal from Representative Brown-Waite of Florida for a federal fund similar to TRIA in the event of natural catastrophes. *Proponents of TRIA "speak out of the opposite sides of their mouths... the same people will argue that the creation of a natural catastrophe fund is simply a bailout, that it will supplant the private market, or that taxpayers will be subsidizing high-risk areas"*

Al Qaeda has repeatedly expressed its ambition to cause maximal damage in its quest for the expansion of Caliphate rule and Shariah law. However, the accumulation of sufficient materiel and personnel to inflict such damage would expose any plot to overwhelming risk of interdiction by counter-terrorism forces, except if the local level of support for political violence was strong enough to erode the effectiveness of these forces.

Terrorism is a manifestation of asymmetric warfare: the resources accessible to terrorists are a minuscule proportion of the military resources of a nation state. The most effective means by which terrorists might actually inflict maximal damage is through the application of leverage. A highly leveraged attack is one where the loss impact is a high multiple of the input cost. Vehicle bomb attacks carefully aimed at weakening key load-bearing columns of a building can trigger a complete building collapse, which would not be possible with a miscellaneous undirected attack. The IRA were masters of triggered building collapse, as exemplified by the destruction of the Baltic exchange in the city of London in 1990.

The classic paradigm of a leveraged attack is one involving a passenger plane as target or weapon. 9/11 is of course the most notorious example. But a variant cargo plane attack has also been developed by Al Qaeda as a paradigm of leverage. On 28th October 2010, a UPS flight to Philadelphia from East Midlands airport, UK, was inspected by MI5. On board was a boxed Hewlett Packard copier, containing a cartridge with explosives, rather than toner powder. This box originated in Sana'a, Yemen. Earlier, a cargo plane had crashed, most likely due to such an improvised bomb attack. Al Qaeda celebrated in its Inspire Magazine, *'Two Nokia mobiles, \$150 each, two HP printers, \$300 each, plus shipping, transportation and other miscellaneous expenses add up to a total bill of \$4,200. That is all what Operation Hemorrhage cost us. This is what we call leverage'*. By comparison, consider the Navy Seal team raid on Osama bin Laden's hideout in Abbottabad in 2011. The Al Qaeda leader had an AK-47 at his disposal; the Navy Seal team had the best equipment possible, including night vision goggles each costing \$65,000.

## 7. SURPRISE AND BLACK SWANS

Although the CIA was aware that Al Qaeda was planning somehow to strike the USA, what happened on the morning of 9/11 came as an unanticipated shock and surprise to the intelligence services. This failure of imagination is often cited as a classic example of a Black Swan event (Taleb, 2007). Ever since then, the spectre of another great surprise attack has haunted the imagination of all those professionally involved with terrorism, including insurers of terrorism risk. To the extent that 9/11 was an event previously described in works of fiction, novelists were subsequently invited by the security forces to share their imaginative insights on potential new modes of terrorist attack.

It is salutary to look back at twelve years of global experience of terrorist plots since 9/11. It is inevitable that where defences have been strengthened, terrorists will seek innovative ways of circumventing improved security. Thus although there has not been a serious attempt to hijack and take over the flight control of an aircraft, there have been audacious attempts, using clandestine shoe, underwear and liquid explosive bombs, to bring down passenger aircraft.

Terrorists do not have their own military aircraft with which to take on the air forces of their nation state adversaries. Within the context of asymmetric warfare, vehicle bombs have been described as the terrorists' air force. Terrorists have been ingenious in acquiring different types of explosive materiel, (fertiliser, propane gas, C4 etc.) with which to make improvised vehicle bombs. Since 9/11, vehicle bombs have been the predominant weapon used around the world by terrorists to cause death and destruction. Against the western alliance, vehicle bombs have also been the most potent of terrorist plots.

Since 9/11, there has been no shortage of chatter on Jihadi websites expressing interest in weapons of mass destruction. There have been attempts at making small quantities of ricin and other toxic chemicals, but sustained counter-terrorism denial of safe havens for laboratories has precluded the development or procurement of weapons of mass destruction. It may further be remarked that counter-terrorism pressure has denied terrorists the opportunity to develop other surprise modes of weaponry capable of causing mass casualties or destruction on the scale of 9/11.

Popular imagination of possible terrorist attack modes has far surpassed reality. The hijacking of the NASA space shuttle is one of the most extreme scenarios put forward by a rating agency. In the USA and elsewhere in the western alliance, terrorism is a control process. Irrespective of what scenario a terrorist cell may contemplate, it could not be brought to fruition without the plot coming under intense counter-terrorism pressure, and most likely interdicted.

In contrast with terrorist attacks since 9/11, surprise has been a regular feature of the global natural hazard environment. With surprise has come enormous insurance loss as well: Hurricane Katrina 2005; Tohoku earthquake 2011; Christchurch earthquake 2011; Thailand floods 2011; Hurricane Sandy 2012. The term 'Acts of God' no longer sits comfortably with scientific insurance documentation on meteorology and seismology. Yet, more than any scientific jargon, this term still conveys to the insurance industry a fundamental principle about natural hazards: Extreme events may occur that mankind has no power to stop.

### Multiple Events

A characteristic hallmark of Al Qaeda spectacular terrorist attacks has been synchronous attacks at multiple targets. A terrorist campaign may extend over months or years, or even decades, but there is tactical value in strikes timed to occur either simultaneously, or within minutes or a few hours of each other. First, the loss impact is increased. Secondly, the terror spread through the population attacked is greatly magnified. Thirdly, the counter-terrorism response to deal with the kind of attack perpetrated would take time to organize and implement. If attacks were undertaken as a sequence over several weeks, rather than on the same day, it is likely that heightened measures to deal with the evolving threat would mitigate the risk considerably.

The viability of catastrophe insurance requires clarity over insurance contract and claims entitlement. Ambiguity can lead to contested claims argued at arbitration or in court. An explicit hours rule, e.g. 72 or 168 hours, can limit the time since the first loss within which other losses can be aggregated within a single catastrophe.

The legal controversy as to whether the destruction of the two towers of the World Trade Center in New York on 9/11 was one or two events was acrimonious and protracted. But at least this was not an hours clause issue; the towers were attacked within minutes not hours of each other. Al Qaeda did plan another wave of attacks in the succeeding months. Richard Reid's shoe-bombing attempt to bring down a transatlantic passenger jet in December 2001 was only an explosive ignition away from being successful. If one were to use a natural hazards metaphor, this second aviation attack within three months might have been perceived as an aftershock of the main 9/11 shock.

Terrorists pay no heed to insurance hours clauses in their attacks – and neither do natural hazards. The traditional concept of an earthquake aftershock is an event of size not greater than that of the mainshock which occurs as a direct consequence of the mainshock. Typically, aftershocks occur as further ruptures of the principal fault zone associated with the mainshock. However, seismological advances in monitoring acknowledge that an earthquake can cause stress changes that could trigger another earthquake a long distance away geographically, and temporally. Thus the M9 Tohoku earthquake of 11 March 2011 triggered other earthquakes in the region. In New Zealand, the September 2010 Darfield and February 2011 Lyttleton earthquakes were linked together, even though quite widely separated in space and time. The re-definition of the term 'aftershock' to include stress-triggered events elevates the event multiplicity issue to a higher level of insurance concern.

## 8. COMMENTARY ON STATEMENTS ON TERRORISM RISK MODELING

*A boundary between non-calculability and calculability:*

*"Let me begin by stating some very simple facts... We do not know where it is going to occur. We do not know when it is going to occur. We do not know how often it is going to occur. And we do not know how much it is going to cost when it does occur". (Csiszer, President and CEO, Property Casualty Insurers of America, US House, July 27, 2005: 54).*

Probabilistic catastrophe risk modeling has superseded deterministic estimates of Probable Maximum Loss because we do *not* know, in a deterministic sense, where events are going to occur; when they are going to occur; how often they are going to occur; and how much it is going to cost when they do occur. This applies to any catastrophe event, whether natural or manmade. We lack knowledge of future events, but we do have knowledge about the principles governing the occurrence of future events. In the case of hurricanes and earthquakes, these principles come from the quantitative science of meteorology and seismology. In the case of terrorism, these principles come from the quantitative science of human conflict, control and game theory, and social network analysis. As with natural hazards, terrorism risk is calculable in a probabilistic, non-deterministic, sense. As emphasized above, the fact that terrorism is a control process restricts significantly the volatility of terrorism losses.

*The insurance industry "can predict, not with precision, because this is not a precise thing... but you can predict... it is doable and is being done (Hunter, Director of Insurance Consumer Federation of America, Senate, May 18, 2004: 69.)*

Catastrophe modelling does not aim to predict the future, but rather to provide a probabilistic framework for quantifying insurance risk. Catastrophe modeling of both natural and manmade hazards is doable and is being done.

## 9. REFERENCES

- Brown-Waite, G. (2007). Policy options for extending the terrorism risk insurance act.
- Kiln R.J. *Reinsurance in practice*.
- Neumann P.R. (2013) The trouble with radicalization. *International Affairs*, 89, 873-893.
- Vaughan E.J., and Vaughan T. (2003), *Fundamentals of Risk and Insurance* (Hoboken, NJ: John Wiley & Sons, p. 41.
- Webel B. (2013) Terrorism risk insurance: issue analysis and overview of current program. CRS Report for congress, R42716.