THE GENEVA ASSOCIATION
Risk & Insurance Economics

The Geneva Reports
Risk and Insurance Research

www.genevaassociation.org

Extreme events and insurance: 2011 annus horribilis

edited by Christophe Courbage and Walter R. Stahel

No. 5
March 2012

The Geneva Association

(The International Association for the Study of Insurance Economics

The Geneva Association is the leading international insurance think tank for strategically important insurance and risk management issues.

The Geneva Association identifies fundamental trends and strategic issues where insurance plays a substantial role or which influence the insurance sector. Through the development of research programmes, regular publications and the organisation of international meetings, The Geneva Association serves as a catalyst for progress in the understanding of risk and insurance matters and acts as an information creator and disseminator. It is the leading voice of the largest insurance groups worldwide in the dialogue with international institutions. In parallel, it advances—in economic and cultural terms—the development and application of risk management and the understanding of uncertainty in the modern economy.

The Geneva Association membership comprises a statutory maximum of 90 Chief Executive Officers (CEOs) from the world's top insurance and reinsurance companies. It organises international expert networks and manages discussion platforms for senior insurance executives and specialists as well as policy-makers, regulators and multilateral organisations. The Geneva Association's annual General Assembly is the most prestigious gathering of leading insurance CEOs worldwide.

Established in 1973, The Geneva Association, officially the "International Association for the Study of Insurance Economics", is based in Geneva, Switzerland and is a non-profit organisation funded by its members.

Chairman: Dr Nikolaus **von Bomhard**, Chairman of the Board of Management, Munich Re, Munich.

Vice Chairmen: Mr John **Strangfeld**, Chairman and CEO, Prudential Financial, Inc., Newark; Mr Kunio **Ishihara**, Chairman of the Board, Tokio Marine & Nichido Fire Insurance Co., Tokyo; Mr Michael **Diekmann**, Chairman of the Management Board, Allianz SE, Munich.

Members of the Board: Dr Carlo **Acutis**, Vice President, Vittoria Assicurazioni S.p.A., Turin; Dr Sergio **Balbinot**, Deputy CEO, Assicurazioni Generali S.p.A., Trieste; Mr Henri **de Castries**, Chairman of the Management Board and CEO, AXA Group, Paris; Mr Patrick **de Larragoiti Lucas**, President, Sul America Seguros, Rio de Janeiro; Prof. Denis **Kessler**, Chairman and CEO, SCOR, Paris; Mr Michel **Liès***, Group CEO, Swiss Re Group, Zurich; Mr José Manuel **Martínez**, Chairman, MAPFRE SA, Madrid; Mr Mike **McGavick**, CEO, XL Group plc, Hamilton; Mr Andrew **Moss**, CEO, Aviva plc, London; Mr Martin **Senn**, CEO, Zurich Financial Services, Zurich; Mr Tidjane **Thiam**, Group Chief Executive, Prudential plc, London; Dr Richard **Ward**, CEO, Lloyd's, London; Dr Yan **Wu**, Chairman and President, The People's Insurance Company (Group) of China Ltd., Beijing.

Secretary General and Managing Director: Mr Patrick M. **Liedtke**, Geneva.

Vice Secretaries General: Prof. Jan **Monkiewicz** (Head of PROGRES and Liaison - Eastern Europe), Warsaw; Mr Walter **Stahel** (Head of Risk Management), Geneva.

Heads of Programmes and Research Directors: Dr Etti **Baranoff** (Research Director for Insurance and Finance), Richmond; Dr Christophe **Courbage** (Research Director and Head of Health & Ageing and Insurance Economics), Geneva; Mr Daniel **Haefeli** (Head of Insurance and Finance), Geneva; Mr Donald **Inscoe** (Head of Institutional Relations), Basel; Mr Anthony **Kennaway** (Head of Communications), Geneva; Prof. Krzysztof **Ostaszewski** (Research Director for Life and Pensions), Normal, Illinois.

Special Officers: Mr Katsuo **Matsushita** (Liaison—Japan & East Asia), Yokohama; Mr Richard **Murray** (Head of Liability Regimes Project), New York; Mr Gordon **Stewart** (Liaison—North America), New York; Dr Hans Peter **Würmli** (Chairman of Chief Risk Officers Network), Zurich.

Chairman of the Scientific Advisory Council: Prof. Harold **Skipper**, Georgia State University, Atlanta.

Former Presidents of The Geneva Association: Mr Raymond **Barre**, Paris (1973-1976); Mr Fabio **Padoa**, Trieste (1976-1983); Mr Julius **Neave**, London (1983-1986); Prof. Dr Dr e.h. Reimer **Schmidt**, Aachen (1986-1990); Sir Brian **Corby**, London (1990-1993); Drs. Jan H. **Holsboer**, Amsterdam (1993-1999); Mr Walter **Kielholz**, Zurich (1999-2003); Mr Henri **de Castries**, Paris (2003-2008); Mr Martin J. **Sullivan**, New York (2008); Mr Jacques **Aigrain**, Zurich (2008-2009).

Extreme events and insurance: 2011 annus horribilis

The Geneva Association
53 Route de Malagnou,
CH-1208 Geneva,
Switzerland
E-mail: *secretariat@genevaassociation.org*
Tel: +41-22-707 66 00
Fax: +41-22-736 75 36

www.genevaassociation.org

March 2012

© The Geneva Association

The Geneva Reports—Risk and Insurance Research No. 5
Extreme events and insurance: 2011 annus horribilis
edited by Christophe Courbage and Walter R. Stahel

The opinions expressed in The Geneva Association publications are the responsibility of the authors. We therefore disclaim all liability and responsibility arising from such materials by any third parties.

Published by The Geneva Association (The International Association for the Study of Insurance Economics)

ISSN 1662-3738

Contents

Acknowledgements

This Geneva Report is the result of a collective effort involving several leading experts from the (re)insurance industry and universities as well as Geneva Association collaborators.

It is part of The Geneva Association's mission to anticipate, identify, analyse and communicate trends that shape the global world of risk and insurance.

We would like to thank the authors for their thoughtful contributions, and The Geneva Association staff for their support—in particular Françoise Jaffré for her copy-editing as well as lay-out and production management work and Samantha Solida for her editing.

Foreword

Michael Butt

2011 has been a record year for natural catastrophes. Economic losses were unprecedented, reaching more than a third of a trillion dollars. Insured losses have reached a record at an estimated US$105 billion, topping, in absolute terms, the 2005 losses of US$101 billion (Munich Re, 2012) caused, inter alia, by the Atlantic hurricanes, Katrina, Wilma and Rita. It has also continued an unwelcome trend of increasingly severe and costly natural catastrophes with a series of extreme events that included the tragic 11 March earthquake and subsequent tsunami in Japan, the flooding in both Australia and Thailand, the New Zealand earthquakes and the U.S. tornadoes.

Whilst the focus of many insurers had settled on North American climate-based events as the cause of heavy claims, 2011 provided a stark reminder of the potential for natural catastrophes elsewhere in the world and not exclusively related to the climate. As the authors of Chapter 1 of this report state, "*the year 2011 has set new records both in terms of economic losses and insured losses caused by natural catastrophes. Also the patterns of these losses and distribution to the different perils have been quite different from the long term experience*."

Indeed, 2011 has been unusual with regards to the regional distribution, as the majority of disasters happened in Asia, and to the focus on geophysical events, as 47 per cent of losses were due to earthquakes. Globally, the number of catastrophe events was 820, in line with the 10-year 2001-2010 average of 790. But one consistent theme is the global need for adaptation and risk reduction measures to reduce the impact of such events.

The impacts of extreme natural events are influenced by a number of local factors. These include preventive measures (wind and earthquake resistant buildings and infrastructures), technical and organisational vulnerabilities and societal resilience (climate-resilient communities), behaviour and pre-event information of the populations at risk. Insurers can help to reduce the hazard potential of extreme weather events by collaborating with their customers as well as with government bodies.

Although relief efforts united people around the globe and the governments of affected countries professed to do their best to help and protect their citizens, little advancement has been made in the wake of the 2011 disasters on the underlying question as to how to deal with the existing vulnerabilities and the risks they are exposed to.

Few governments have thoroughly revisited their national risk management—if they even have one. In 2012, governments must make progress in understanding the risks their countries and citizens are exposed to and how to manage them properly. Like companies, they should establish comprehensive risk management processes. The techniques and tools are readily available and while paradoxically many governments expect their industries, and especially the high-risk industries, such as nuclear, chemical or transport, to install efficient enterprise risk management systems, they themselves often neglect to do so at the national level.

The first step in this process must be the recognition of the vulnerabilities present and the risks facing them. Then there needs to be a proactive approach for dealing with them. For example, the impact on vital infrastructure from natural catastrophes or the degree of reliance on new technologies such as the Internet or the "cloud" by essential services represent risks that are not always well enough understood and often not well managed. The second step would be to implement policies that facilitate the use of risk management and that help set the right incentives for people and institutions to behave in a risk adequate manner. Whilst governments have focused a lot of their attention on getting to grips with the financial crisis, they must also not be distracted from the very significant financial and human impacts that natural catastrophes and other risks have. Inadequate risk management on the national level can only too easily lead to social instability and chaos.

This also applies to the private sector for which ignoring the lessons of risk management can multiply economic vulnerability. The global manufacturing supply chain, for example, ignores that economy of scale always goes hand in hand with dis-economy of risk: the smaller the number of plants, the higher the risk of interruptions. And the bigger the distances between the members of the supply chain, and the smaller the stocks, the higher the risk of interruptions of the supply chain.

The natural disasters of 2011 increased the awareness of many multinational companies to the vulnerabilities of supply chains that they have perfected for years to make them more efficient in order to lower costs. The earthquake and tsunami that hit Japan last March caused parts shortages, particularly among the manufacturers of auto and electronics, and made companies realize the fragility of supply chains. The floods in Thailand at the end of 2011 interrupted the supply chains of global manufacturing a second time, sometimes hitting the same companies. But business interruption at, or even the resulting bankruptcy of, suppliers may have no direct financial repercussions on the global manufacturers themselves. The increased awareness does then not lead to changes, primarily because increasing inventory even by a small amount to avoid supply shortages can cost large companies millions of dollars.

Enough consideration should be given in the future to the establishment of adequate real world risk management (as opposed to only financial risk management) by governments. The insurance industry stands ready to contribute and share its significant body of expertise and knowledge on risk management. Insurers can help in several ways: For instance, they can help in catastrophe modelling and in providing economic incentives to discourage, for instance, construction in high-risk areas. They can contribute to the collection of data on the cost of extreme events, to the promotion of risk awareness, of resilient reconstruction methods after losses and of adaptation solutions. They can also provide market-based incentives to prevention as well as risk retention and risk transfer mechanisms.

However, the nature and scale of the challenge of natural catastrophes is greater than can be covered by insurance alone. As the reason for increasing damages and losses are socio-economic changes, more than changes of natural variability, a closer cooperation and collaboration between governments, industry and insurers is needed to reduce disaster risks and the economic, social and human costs of natural catastrophes. This must be a moral and economic imperative.

This report is one of the many activities carried out under the auspices of the Climate Risk and Insurance (CR+I) research project which was initiated by The Geneva Association members at the 2008 General Assembly in Hamilton, Bermuda. The project is a logical further step in the development of the Risk Management Research Programme established by The Geneva Association in 1973.

A project working group has been established to study the relationship between climate risks and insurance and to coordinate the project development. The main objectives of the CR+I research project have been to identify and analyse:

- issues that are of specific relevance to the insurance industry, such as possible future claims developments, new business opportunities and scenario testing;
- external challenges to be addressed at the political, educational and social levels, such as the role of government-specific provisions concerning, e.g. building codes, zoning restrictions, etc.; and,
- the frontier between risks and opportunities from extreme weather events and those from climate change.

One of the early conclusions of this project has been that adaptation is a key issue for insurance, including measures of disaster risk reduction and building disaster resilient communities, which help to protect populations against any natural catastrophe. The challenges created by the multitude of natural catastrophes and climate related disasters in 2011 have starkly underlined this conclusion.

The year 2011 then, was unquestionably an annus horribilis in terms of natural catastrophes and this publication offers a reflection on these events. Once again The Geneva Association has managed to put together a series of high quality contributions providing us with both a global and detailed picture of the 2011 events. These contributions also offer a rigorous analysis of the role and mechanisms of insurance in managing climate risk and other extreme events. I am confident that this report will prove to be useful in the global debate of how to manage efficiently the risks linked to extreme events.

Michael Butt
Chairman, AXIS Capital Holdings
and co-Chair of the CR+I Project

Part 1

Extreme Events and Insurance

1. Characteristics of the extreme events in 2011 and their impact on the insurance industry

Peter Höppe and Petra Löw

1. Introduction

The year 2011 has set new records both in terms of economic losses and insured losses caused by natural catastrophes. Also the patterns of these losses and distribution to the different perils have been quite different from the long-term experience. The disaster in Japan on 11 March 2011 has made clear how vulnerable society and the economy are in the face of geophysical events, which have been receiving less attention in recent years due to the all-pervading discussion on climate change. The Tohoku earthquake was also the first natural disaster leading to long-term policy changes in several countries far away from the affected region like the nuclear phase-out in Germany and Switzerland and the cancellation of all plans to start building nuclear power plants in Italy.

In this chapter we analyse the specific patterns of natural extreme events in 2011, which have caused significant losses both for the affected economies and insurance industry. The analyses are based on data from the Munich Re NatCatSERVICE,[1] the world´s most comprehensive database on loss-relevant natural events. The database records all natural hazard events that result in property damage or personal injury. Depending on their monetary and humanitarian impact, the events are classified into six categories, ranging from minor losses to major natural disasters.

The assessment of overall losses in NatCatSERVICE consists of direct (tangible) losses plus, in the event of business interruption, the resulting indirect losses. Quantitatively, by far the greater share of the losses relates to tangible assets. For the most part, consequential losses (indirect and secondary losses) are not taken into account. Direct losses are immediately apparent, quantifiable damage to or the loss of, for example, residential properties, schools, hospitals, vehicles, agricultural assets (affected acreage, buildings, machinery and livestock) or infrastructure. Direct losses include the costs of repair, replacement and clean-up. The insured losses are derived from data from insurance industry initiatives like PCS (Property Claims Services) or PERILS,[2] national insurance associations as well as from claims data of individual insurance companies. All loss figures in the analyses have been adjusted for inflation and thus show the losses in 2011 US dollars values.

1 *http://www.munichre.com/en/reinsurance/business/non-life/georisks/natcatservice/default.aspx*

2 PERILS, jointly established by Munich Re together with seven European-based insurers, is an independent Zurich-based company that aims to aggregate and supply European catastrophe insurance data to subscribers in the insurance industry.

Currently NatCatSERVICE comprises more than 30,000 data sets of loss events. Since 1980 all loss-relevant events are documented on a global level, for the great catastrophes even since 1950. More than 200 sources of information are used to collect the data like news agencies, weather and geophysical services, insurance-related associations, scientific institutions and many others.

The events are classified in four event categories relating to the origin of the perils. The four categories cover all kinds of natural events, which may cause damages and losses:

- **Geophysical events:** earthquakes, tsunamis, dry mass movements and volcanic eruptions.
- **Meteorological events:** all kinds of storms, like tropical cyclones, winter storms, tornadoes and other thunderstorm related perils.
- **Hydrological events:** river floods, flash floods, storm surges and wet mass movement.
- **Climatological events:** all kinds of extreme temperatures like heat and cold wave, drought and forest fire.

In all figures of this chapter geophysical events are shown in red colour, meteorological events in green, hydrological events in blue and climatological events in orange.

2. The annus horribilis 2011

2.1. The figures of the year

In the world map of natural catastrophes of 2011 (Fig. 1) all loss-relevant natural events are shown. The large dots represent the most devastating events. The map shows that nearly every country has been affected by some kind of natural loss event. In the Americas all large loss events have been related to extreme weather while in Asia and Oceania many of them have been of geophysical origin. We recorded 820 loss-causing events, which roughly corresponds to the average for the past ten years with 790 events.

2011 has been the most expensive year in recorded history both for the national economies and the insurance sector. With direct economic costs of US$380bn, 2011 far surpassed 2005, previously the costliest year on record. Original insured losses totalled US$105bn, slightly more than 2005's US$101bn (in original values). In inflation-adjusted figures, however, 2005 with US$117bn still stays the year with the highest insured losses.

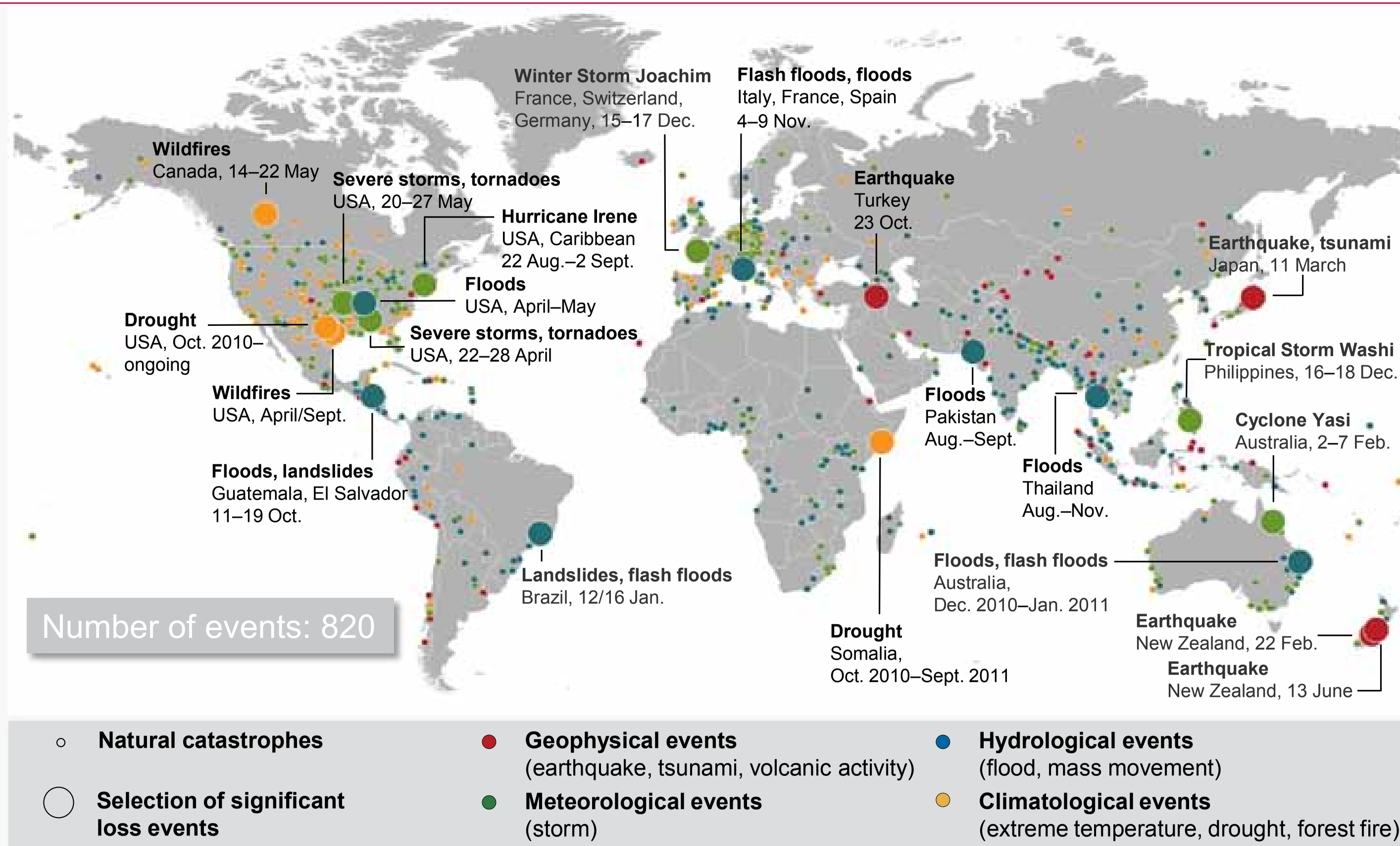
While most of 2005's losses stemmed from hurricanes Katrina, Rita and Wilma, 2011 was dominated by the devastating earthquake disasters in Japan and New Zealand, which alone accounted for overall losses of US$235bn and insured losses of about US$50bn.

To these were added very high overall and insured losses from weather-related events, which in terms of number of events made up nearly 90 per cent. Both the direct economic losses and the insured losses resulting from weather-related natural catastrophes reached the second-highest values recorded since 1980 (in 2011 currency units). So, even without the earthquakes 2011 would have been an extreme natural catastrophe year.

2.2. Trends in natural catastrophes

Figures 2 and 3 show the long-term statistics since 1980 in the development of the annual number of events (Fig. 2) and the annual overall and insured losses (Fig. 3).

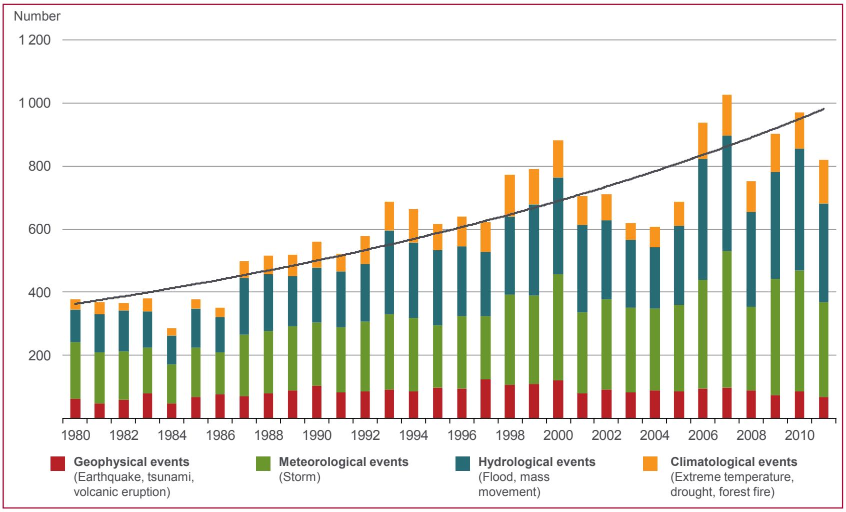
Figure 1: 2011 world map of natural catastrophes



Source: Munich Re, NatCatSERVICE, as at January 2012

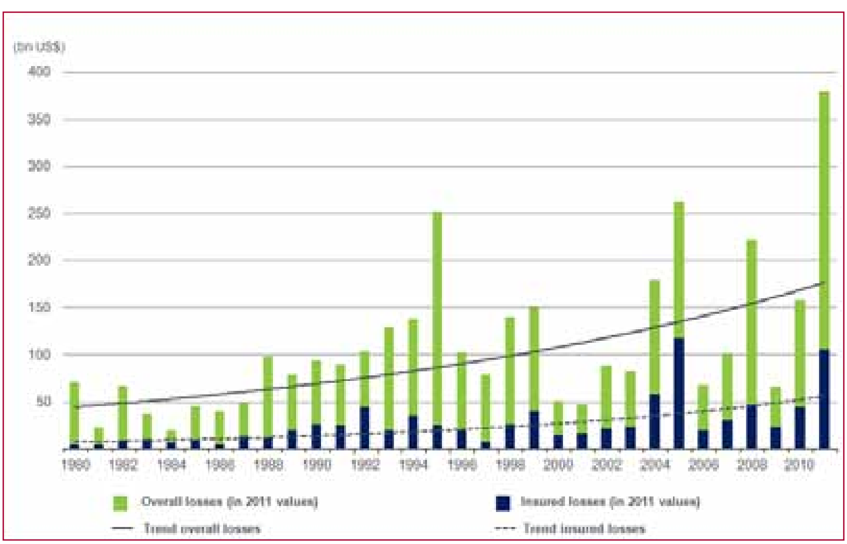
As regards the frequency of natural loss events the number of natural catastrophes has been rising almost continuously since the 1980s. In the last 31 years the global number of loss-relevant events has increased from about 400 per year to about 1,000 (Fig. 2). In terms of the frequency of events 2011 has not been a record year, as with 820 events it is only ranked 6th.

Figure 2: Annual number of natural catastrophe events globally from 1980–2011



Source: © 2012 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – as at January 2012

Figure 3: Annual total economic and insured losses caused by of natural catastrophes globally from 1980–2011



Source: © 2012 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – as at January 2012

Concerning the economic losses (Fig. 3), however, 2011 is an outlier. The economic losses in 2011 have exceeded the previous record of 2005 by 46 per cent. The annual loss figures clearly are dominated by a few extreme events, in 1995 by the Kobe earthquake, in 2005 by hurricane Katrina and in 2011 by the Tohoku earthquake.

2.3 Loss of human lives

Since 1980, natural disasters have claimed the lives of more than two million people around the world and deprived many millions more of everything they once owned. In 2011, natural catastrophes claimed the lives of 27,000 people, far fewer than the long-term average and in stark contrast to the average since 1980 of 73,000 per year. The severe earthquake and tsunami in Japan caused 15,840 fatalities. In Brazil, 900 people were killed by landslides. About 2,500 people died in the devastating floods in Thailand (813 fatalities), Pakistan (520 fatalities) and in the Philippines (1,257 fatalities). The series of tornadoes in the U.S. in April and May 2011 resulted in 585 fatalities. According to estimates from the United Nations, the catastrophic drought and consequent famine in the Horn of Africa has affected millions of people. This was one of the year's greatest humanitarian catastrophes and killed more than 50,000 by famine (amount of famine fatalities are not included in the Munich Re annual figures).

2.4 Distribution of natural catastrophes to intensity classes

The following five events of 2011 (Table 1) fall into the highest loss category 6, "great" natural catastrophes. The top-most category is defined by the following criteria: the event gives rise to fatalities numbering in the thousands and/or homeless numbering in the hundreds of thousands and/or a substantial economic/insured loss.

Table 1: Great natural catastrophes in 2011

Date	Event	Region	Overall losses in US$m	Insured losses in US$m	Fatalities
22 Feb.	Earthquake	New Zealand	16,000	13,000	181
11 March	Earthquake, tsunami	Japan	210,000	35,000-40,000	15,840
22-28 April	Tornado outbreak	USA	15,000	7,300	350
Aug.-Nov.	Floods	Thailand	40,000	10,000	813
2010-2011	Drought	East Africa			>50,000

Source: Munich Re, NatCatSERVICE

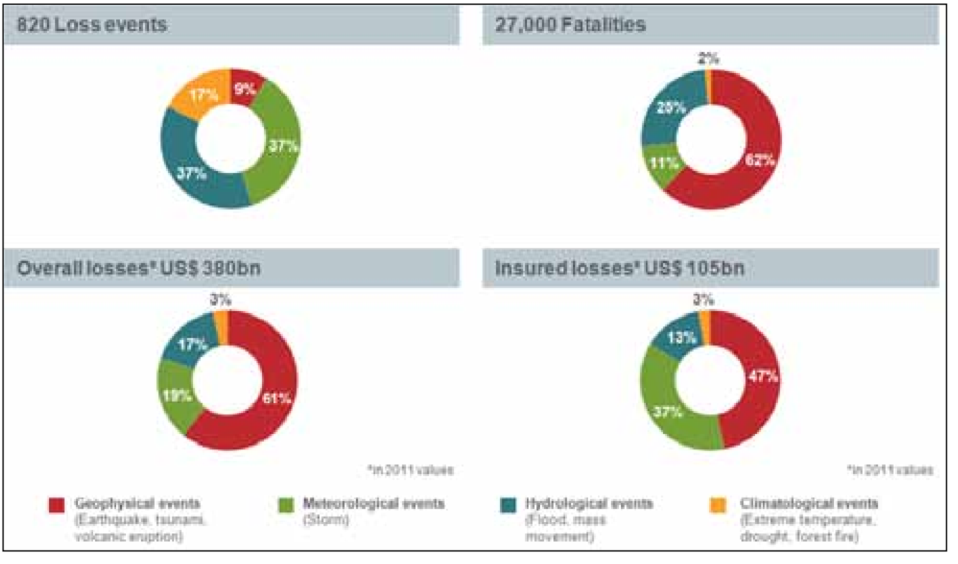
In 2011 besides five "great natural catastrophes" (see Table 1) 35 events fell into the category of "devastating catastrophes" (category five, i.e. events entailing more than US$650m in losses and/or more than 500 fatalities). Below the category "devastating catastrophes" there were 60 events in the "severe catastrophe" category 4 (more than US$250m in losses and/or more than 100 fatalities).

The distribution of the 820 loss events in 2011 among catastrophe classes 1 to 6 corresponded roughly to the average distribution of loss events in the years 1980 to 2010. One difference was discernible in category 1 (small-scale loss events). While 40 per cent of all events fell into this category in the period from 1980 to 2010, only 35 per cent were deemed small-scale in 2011. Thirteen per cent of the events recorded in the 1980 to 2010 period fell into category 3, i.e. severe catastrophes, but in 2011, this percentage rose to 17 per cent.

2.5 The distribution of types of events

Figure 4 shows the breakdown of the number of loss events according to the main hazards. For 2011 this has been more or less in line with the average over the past 30 years. In 2011, 91 per cent of the global natural catastrophes have been weather-related events. The largest contributions with 37 per cent each came from meteorological (300 storms) and hydrological events (310 floods, storm surges, mass movements). The category of “climatological events”, i.e. wildfires, droughts, heat waves and cold waves, contributed 17 per cent (140 events, 117 of them wildfires). Nine per cent fell into the category of geophysical natural hazards, namely 54 earthquakes and 16 volcanic eruptions that caused personal injury and/or property damage.

Figure 4: Natural catastrophes globally 2011, percentage distribution



Source: Munich Re, NatCatSERVICE, as at January 2012

The distribution of fatalities in 2011 deviated from the long-term statistics. While the average contribution of geophysical events to the annual number of fatalities has been 38 per cent it has reached 62 per cent in 2011. The ratio of fatalities caused by flood events in 2011 reached 25 per cent while the average for the last 30 years has been less than half of it (11 per cent). The part of climatological events (predominately heat waves) with 2 per cent only has been significantly lower in 2011 in comparison to the long-term average value of 32 per cent.

2011 has been exceptional not only due to its extraordinarily high losses, but also because of significant deviations of the distribution of the losses to the different perils. After 15 years in which weather-related natural catastrophes had consistently been the prime cause of losses, in 2011 61 per cent of the economic losses have been due to geophysical events. The long-term average contribution of geophysical events has been just 22 per cent. 2011 with 19 per cent (long-term average 41 per cent) has been one of the years with the lowest ratios of storm related economic losses. The ratios of the other two groups of perils have not deviated very much from the long term averages.

The highest insured losses (Table 2) were caused by the earthquakes in Japan (US$35-40bn) and New Zealand (US$13bn) and by the series of tornadoes that swept the United States in April and May (US$25bn). Flooding in Thailand also set a new loss record of about US$10bn, making it not only the country's most expensive catastrophe to date, but also the world's most expensive flood disaster. Due to the dominant geophysical events the distribution of the insured losses to the different perils in 2011 has been quite untypical. Geophysical events contributed 47 per cent to the insured losses, in contrast to only 10 per cent on the long-term average.

As 2011 has been a year also with extreme floods, the losses caused by them (US$14 bn) accounted for 13 per cent of all insured losses, which is 5 per cent up from the 8 per cent long-term average ratio. The most expensive events in this category were floods in Australia (in January) and Thailand (from August to November).

While the long-term average ratio of storm-related insured losses has been 76 per cent of all insured losses in 2011 it only reached 37 per cent. One reason for this was the relatively harmless hurricane season, which, despite numerous (19) tropical storms, caused only moderate insured losses of about US$7.5bn, in contrast to the ten year average of US$17bn. Devastating thunderstorms and tornado outbreaks in the U.S. engendered extreme high losses for the insurance industry, adding up to about US$26bn. This is an absolute record for this kind of peril as losses have been more than double the previous record in 2010. The insured losses of these events have contributed more than 50 per cent of all insured storm losses in 2011.

Table 2: 2011's most expensive natural catastrophes for the insurance industry

Date	Event	Region	Overall loss (US$m)	Insured loss (US$m)	Fatalities
11 March	Earthquake, tsunami	Japan	220,000	35,000 - 40,000	15,840
22 Feb.	Earthquake	New Zealand	16,000	13,000	181
Aug.-Nov.	Floods	Thailand	40,000	10,000	813
22-28 April	Tornadoes	USA	15,000	7,300	350
22 Aug.– 2 Sept.	Hurricane Irene	USA, Carib.	15,000	7,000	55

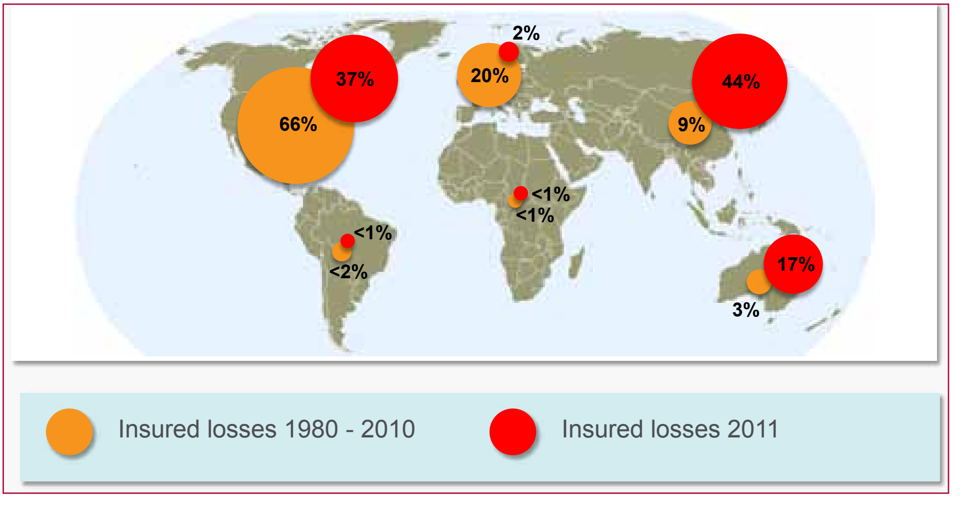
Source: Munich Re, NatCatSERVICE, as at January 2012

2.6 Continental distribution of natural catastrophes

The relative breakdown of numbers of loss-relevant natural extreme events by continent in 2011 has been in line with the long-term average with most catastrophes occurring in the Americas (290) and Asia (240) followed by Europe (150), Africa (80) and Australia/ Oceania (60).

The distribution of insured losses between the continents in 2011, however, differed markedly from the average geographic distribution in the period from 1980 to 2010 (Fig. 5). Asia had the largest share (44 per cent), in stark contrast to the average over the last 31 years, which was only 9 per cent. In 2011 Australia/Oceania accounted for 17 per cent of all insured losses, far more than on average in the reference period 1980-2010 (3 per cent). Loss ratios were much lower in North America (37 per cent in 2011 vs. 66 per cent long-term average) and especially Europe (2 per cent in 2011 vs. 20 per cent long-term average).

Figure 5: Comparison of relative distributions of insured losses per continent in 2011 versus the long-term (1980-2010) averages



Source: Munich Re, NatCatSERVICE, as at January 2012

3. Conclusion

2011 has been an absolute record year as far as economic and insured losses caused by natural extreme events are concerned. But it also has shown very untypical patterns of the distribution of the losses to the different perils. After 15 continuous years during which weather-related catastrophes have been the main driving force behind the damage and losses, the year 2011 reminded how unstable the Earth is. Already in 2010, the earthquakes in Haiti and Chile and the eruption of the volcano Eyjafjallajökull in Iceland had drawn attention to geophysical hazards. The 2010 material losses incurred were, however, only approximately half as high as those caused by extreme weather events. Over the past 31 years, the losses caused on average by geophysical events accounted for 22 per cent of the economic losses but only 10 per cent of the insured natural disaster losses. In 2011 these ratios have been 61 per cent (economic) and 47 per cent (insured). So a message of 2011 certainly is that geophysical risks must not be forgotten despite the quickly rising weather-related risks.

In recent years, the headlines have often featured the increases in extreme weather events, which most probably have some link with climate change. 2011 has shown quite clearly that despite the discussion about increasing weather risks, important as it is, we should not forget the other natural perils. Although the hazards they cause do not have long-term trends, and due to increasing exposures also rising, they still have enormous damage potential.

2. Insurance and extreme events

Christophe Courbage and Walter R. Stahel

1. Introduction

The year 2011 has shown an increasing severity arising from natural catastrophes and has been the costliest natural catastrophe year on record. Three of the 10 biggest natural catastrophes occurred in 2011, among which the Japanese earthquake[1] of 11 March that caused losses estimated at US$220 billion (Munich Re, 2011). Such catastrophes are not only very costly but are also dramatic in terms of human lives lost. According to Swiss Re (Swiss Re, 2011), more than 30,000 people lost their lives due to catastrophes, more than half of them in Japan.

If global warming is likely to play an important role in these events, it appears clearly that a greater concentration of values and of people in potential hazardous regions, as well as a higher interdependence of economic activity in catastrophe-prone areas has led to increasing catastrophic risk vulnerability.

The debate on managing disaster risk is not new. In 1885, the *Encyclopédie des Travaux Publics* (Librairie Polytechnique, 1885) already stated: "*The various attempts to deal with floods seem to show that we cannot avoid this major natural phenomenon. It would be far less destructive if humans had not modified it through unwise operations*". Yet, we had to wait until the middle of the 20th century before catastrophe risk management programmes started to be implemented. Today, the development of risk management theory, empirical catastrophe risk research and increasingly detailed modelling of risks have enabled us to draw a general framework for analysing this issue.

When managing extreme events, several key areas need special attention: risk assessment and risk identification, mitigation and adaptation activities and, finally, the transfer of the risks that cannot be eliminated or reduced through risk-sharing mechanisms. Implementing these mechanisms is not an easy task as one has to take into account the history, the set of institutional arrangements and the financial constraints of each country.

Since insurance has expertise in all these fields, the insurance industry can play an important role in helping society to adapt and become more resilient to natural catastrophes and extreme events.

This chapter, aimed at addressing the role of insurance in managing risk linked to extreme events, is structured into six sections. In section 2, we introduce how insurance operates and the concept of insurability. Section 3 addresses the role of insurance in identifying

1 The Japanese events of 11 March will be analysed in detail in Chapter 5 of this report.

and understanding risk. Section 4 presents the various incentives insurers can implement to develop prevention and mitigation activities. Sections 5 and 6 deal with the role of insurance in developing mitigation activities and risk awareness respectively. Section 7 discusses the level of capital needed by insurers to manage extreme events. Some concluding remarks are provided in the last section.

2. Insurance and insurability

Insurance provides a method to distribute and to reduce the financial risk associated with some adverse events, by sharing costs either between individuals or over time. This method enables individuals to equalise or smooth their available funds over diverse states of the world. Generally speaking, insurance has two main functions, namely to transfer individual risks to a third party and to aggregate or pool risks in order to better assess the probability of occurrence. The insured pays a premium, reducing his or her own wealth, in return for the insurer's agreement to pay some monetary amount to the insured loss that has occurred, under the conditions specified in the contract.

Market insurance coverage includes a specific set of services funded through a risk-based premium that is independent of the insured's wealth or income.[2] The insurance premium equals the average loss of a group of individuals with the same risk profile, plus a share of the costs of administering the system, called loading costs. The role of insurance is therefore to identify groups of individuals with the same risk profile and to establish a premium for this risk. When aggregating many individuals' independent risk exposures, insurers rely on the law of large numbers which allows them to estimate the average expected loss. The larger the sample size (the number of insured), the more precise the risk definition and the more accurate the estimate of the insurance premium is and the lower is the effective risk faced by the insurer.

But in some cases, premiums which are set exclusively on the basis of individuals' risks can make the premium unaffordable for certain high-risk groups. Public authorities then typically impose community-rated premiums that correspond to a complete pooling of premiums across all risk types; this is especially the case for health insurance.

An intrinsic feature of insurance is to diversify risks. As stressed before, the diversification of risks can be achieved by aggregating a very disparate portfolio of risks. But above all, the insurer diversifies risks by accumulating insurance contracts for uncorrelated risks, and then by investing premium in common stock or other assets whose investment risks are uncorrelated, or by reinsuring (devoting to other insurers the function of diversification). In this way, insurance underpins sustainable economic activity, by sharing and spreading the risk of economic losses across society and regions, and reducing the potential consequences for individuals.

Insurability thus is at the core of the insurance business as it can only operate within its limits. A risk is insurable when risk transfer in the private market can be organised so that a prospective policyholder is able to acquire the coverage he needs to combat the adverse financial losses resulting from an uncertain occurrence (Courbage and Liedtke, 2003). Hence, two conditions must be met before insurance providers are willing to offer coverage against an uncertain event. The first is the ability to identify and quantify, or estimate, the probability and consequences of the event occurring. The second is the

2 In the case of public insurance, premiums are mainly funded though income-dependent mechanisms such as social insurance contributions, hypothecated taxes and/or general taxation.

ability to set premiums for each potential customer or class of customers. If these two conditions are both satisfied, a risk is considered to be insurable. Yet, insurers may still opt not to offer coverage against this risk if it is impossible to specify a rate for which there is sufficient demand and income revenue to cover loading factors and claims costs of the insurance and still yield a net profit. In that sense, insurability does not necessarily lead to insurance market.

Insurability requires a framework for efficient operations. Insurance requires losses to have some probability of occurring. The risk characteristics must exist. If it were certain or nearly certain that a person would suffer a particular loss in a particular period, the solution would not be insurance as the risk element is absent. Examples are costs of repairs or simple maintenance for equipment, which like other regular occurrences do not qualify as uncertain events. On the other hand, extremely low frequency events are hardly insurable. If the probability of the occurrence of an event is very low, the historical data may be poor or non-existent, and the risk assessment and risk modelling may be very difficult (insuring earthquakes in areas that are considered as being not at risk might be an example). A last situation concerns the occurrence of events with huge financial consequences. Insuring the risk that a large asteroid hits the Earth is hardly manageable. Even with risk quantification, raising the capacity required would be nearly impossible. Nevertheless, as will be presented later on, recent instruments such as CAT bonds allow the coverage of risks which under standard contracts are not insurable.

Once risks have been identified, and in order to offer coverage against adverse events, insurers must be able to set premiums for each class of customers. There are a number of factors that play a role in determining the premium an insurer would like to charge. In particular, the limits to insurability in economic terms are dictated by the need to control the adverse selection and moral hazard phenomena that result from the so-called information asymmetries between insured and insurer.

Adverse selection occurs when insurers, because they do not have proper information about the risk of the insured, are not able to differentiate insurance premiums on a risk basis. Insurance then becomes too expensive for ‘‘good risks’’, ultimately leaving the insurer with the “bad risk”, and creating a situation of income deficit. To fight against adverse selection, insurers need to adapt their techniques to obtain adequate information and define risk groups as closely as possible and be able to fix the premium accordingly.

Moral hazard, the second phenomenon, corresponds to a behavioural change resulting from an individual’s insurance status. In particular, moral hazard exists because, as the risk is fully insured, the insured party has less incentive to prevent the loss from occurring. Hence, due to this change in behaviour, the probability or severity of potential accidents starts to rise, making the premium too low. If the moral hazard cannot be properly contained, a risk may become uninsurable. In extreme cases, any insurance would be undesirable because the risk of an accident will rise as a result of the availability of insurance. Techniques which allow insurers to minimise moral hazard are well known, whether introducting excesses, keeping the insured exposed to some risk, or making the premium conditional on risk management activities such as prevention measures, for instance installing sprinkler systems in buildings.

Ambiguity is another factor that influences the amount of the premium charged by insurance companies to cover risks. Indeed, there are many instances in which a lack of historical data or imperfect scientific knowledge leads to ambiguity on the loss probability. If the loss probability becomes uncertain, it may be difficult to compute the premium. Thus the higher the uncertainty on the probability of loss and its magnitude, the higher will be the premium charged. As shown by various empirical studies, actuaries and underwriters are so averse to ambiguity that they tend to charge much higher premiums than if the risks were well specified (Kunreuther *et al.*, 1995).

Finally, it is worth stressing that insurance is also constrained through regulatory and legal limitations. National legislation determines and specifies what an insurance company can offer under its license. A new type of cover which is outside the current definition of permitted insurance cannot be offered. Also, certain types of insurance can be deemed to be against public interest.

3. Understanding and identifying the risk

Understanding and identifying risks is the main task of insurers and constitutes the heart of their business. Insurers have developed various tools that make it possible to understand risk better, and in particular extreme events.

To identify risk, estimates are made regarding the frequency at which specific events occur as well as the severity of loss likely to occur; such estimates use historical data of previous events and scientific analyses. Risk assessment is primarily the concern of technicians and engineers. Many tools exist and are used to predict the occurrence of catastrophes, or to identify the fields most at risk. New advances in information technology offer an opportunity to estimate more accurately the probabilities and the potential losses of future disasters. The development of faster and more powerful computers and improved data on hazards, properties and people at risk enable the examination of extremely complex phenomena. Meteorological models for hurricanes and floods and geodesy techniques for earthquakes have been developed in academia and the private sector. Insurers have also gained better skills in understanding natural hazards and developing modern risk evaluation techniques. The identification of hazards and risks is of major importance for setting up mitigation measures and developing risk transfer systems. However, not all these tools are applied as it may be difficult to collect the data needed and share the information between the concerned parties. There is a financial limit to what can be done in poor countries, and corporations do not necessarily have real commercial incentives to implement or diffuse their techniques in catastrophe-prone areas. This is undeniably calling for a greater partnership between both the private and the public sector.

To assist in pricing and underwriting, insurers often seek the assistance of catastrophe modelling firms, also known as CAT modellers. The insurer provides data on its risk exposures to the modeller, who simulates the occurrence of various types of catastrophes, based on various scenarios, and provides the results of the analysis to the insurer. The analysis usually includes probability distribution in the form of a loss exceedance probability curve which depicts the probability that a certain level of loss will be exceeded on an annual basis.

4. Prevention and mitigation

Mitigation measures are *ex ante* activities, undertaken before the catastrophe occurs. They reduce losses in the tail of the distribution, expand the insurance industries capacity and lower prices for reinsurance. But people are reluctant to invest in prevention for a number of reasons. They frequently misperceive the risks they face. They have relatively short-time horizons over which they want to recoup their investment. They also believe that they will only be financially responsible for a small portion of their losses should a disaster occur—a conception which is often true because of liberal disaster relief by nation states. Low-income people are often reluctant to incur the upfront costs associated with protective measures, or they may not be able to afford them.

However, mitigation measures, for instance a well enforced building code, are an efficient way to lower the consequences of catastrophic risk. At the epicentre of the 1999 Turkish earthquake, some buildings remained intact while others surrounding them had collapsed, demonstrating that appropriate design and quality of buildings are crucial. That is the main reason why earthquakes in developed countries kill fewer people than earthquakes in emerging ones.

Developing ways for encouraging governments, businesses and individual households to adopt cost-effective loss reduction measures is crucial. Both the public and the private sectors have a role to play. Insurance companies, to the extent that they are present in the market, provide market-based incentives, such as premium reductions on insurance for well-designed homes or deductibles. A key tool available to insurers is the use of risk-based premiums to incentivise actions to reduce risk. Insurers have a large experience in applying these tools in other lines of businesses such as household fire, burglary, automobile insurance or health insurance. An informative example from Florida illustrates the use of variable insurance premiums to motivate actions to reduce financial consequences from extreme weather events. Following the devastation of Hurricane Andrew in 1992, the State of Florida introduced a law requiring insurance companies in the State to file rates for residential property that included appropriate discounts, credits or other rate differentials for properties that have features designed to reduce the amount of loss in a windstorm. Actions to reduce property vulnerability to hurricane winds, such as fitting window shutters and fixing hurricane straps to hold the roof down, led to reduced insurance costs. Hence, a legislation that precludes risk-based pricing can lead to inappropriate responses from both the public and private sector, and undermine the incentive which created this system. Yet, if risk-based pricing is a way to reduce risks, higher rates in high-risk zones create wide variations in pricing, potentially penalizing those at higher risk, which may have various consequences. It could either deter people from living in high-risk areas, or necessitate the intervention of public authorities to subside premiums for low-income people living in these areas.

In relation to limiting carbon emissions or taking action related to climate change, insurance companies can play various roles, as stressed in a recent publication of The Geneva Association.[3]. This can take the form of insuring new technologies so as to speed up their commercialisation and transfer to the market place. Insurance companies can also invest in and finance clean energy projects and offer eco-friendly funds. Another possibility is illustrated via existing insurance policies that allow policyholders to offset their travel at the point of purchasing motor insurance. In the same way, the pay-as-you-drive policies that have recently became available in various countries also help with mitigation as they encourage less driving. Besides, as stressed by Maynard (2008), many insurers are large investors in equity markets and they can avoid investing in companies that are major carbon dioxide emitters. Even more efficient, insurers can use their voting

3 See The Geneva Association (2009).

rights at general assemblies and engage with the boards of companies in which they invest to foster more sustainable business models.

Finally, the insurance industry can guide and engage customers and suppliers on alternatives in claims-handling that are more climate-friendly and weather-proof. Also, the insurance industry can participate in the formulation of public policy. This includes the participation in wide-ranging discussions linked to the establishment of natural catastrophe pools, the development of improved building codes, the greenhouse gas emissions regulation including fuel-economy standards. The insurance industry also makes policy proposals as a financial industry through participation to international organisations and environmental groups.

5. Adaptation

Adaptation is different from mitigation in the sense that it refers to the ability to adjust to extreme events, to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.

Some good examples of how insurers can promote adaptation, primarily through measures to maintain the insurability of properties in risky areas, are presented in Herweijer *et al*. (2009) and briefly discussed here.

A first example illustrates the provision of information in reducing the vulnerability of properties. The Institute for Business and Home Safety (IBHS) was established by insurance and reinsurance companies in the U.S. as a non-profit initiative to reduce the social and economic effects of natural disasters. In 2004, IBHS published a leaflet aimed at homeowners, providing advice about making properties more likely to survive wildfire, including protection and prevention activities.

Another example illustrates partnerships with policymakers to establish maximum thresholds of acceptable risk. Following extreme inland flooding in 2000 in the U.K. with devastating economic damage, insurance companies agreed to continue offering flood cover to policyholders, but in return called for the U.K. government to take action on greater investment in flood defences. The government subsequently increased its annual expenditure on flood defences by more than 40 per cent and introduced new guidance to flood risk for new projects.

In developing countries, the extension of microinsurance is a way to promote adaptation. Indeed, extending insurance cover in developing countries not only fosters economic development, but also enables countries prone to extreme events to manage these risks more efficiently. An increasing number of insurers are nowadays offering microinsurance products to cover risks related to weather. For instance, demand is growing for index-based climate risk microinsurance programmes as an alternative to crop insurance. In the same spirit, multi-country insurance pools are being implemented as a way to cope with weather-related risks and other extreme events risks. The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is a good illustration of a partnership between various states, international organisations and the insurance industry to provide governments with immediate funds following hurricane or earthquake catastrophes.

6. Risk awareness

Insurers are also well placed to promote and increase risk awareness. They have various channels through which they could inform the general population about the risks they face. First they can publicise their products, so as to increase information about the hazards people face when confronted with extreme events, encouraging individuals to think about their own (lack of) coverage. Second, insurers can be active in developing educational programmes for consumers and school children about these risks and increase awareness about the various forms of coverage available. Some of these activities can be used to explain how land use and construction standards can reduce risk exposure. Other activities can be carried out in partnership with public organisations to increase public risk awareness and reduction education.

A recent OECD report (OECD, 2011) documents how various insurance companies or national federations of insurers have actively informed the general public through advertising campaigns, workshop, brochures, school programmes and websites. For instance, in the aftermath of the 1995 Kobe earthquake, the General Insurance Association of Japan promoted public understanding of hazard and insurance mechanisms through campaigns, elementary school programmes, flyers and advertisements. In part due to these efforts, there has been an increase in earthquake insurance penetration from 33.5 per cent in 2002 to 40.3 per cent in 2006 (OECD, 2011).

The same strategy has been used by the Turkish Insurance Pool to increase earthquake insurance penetration in Istanbul from 15 per cent to nearly 30 per cent in the seven years since the programme's implementation (OECD, 2005). In the same spirit, State Farm Insurance, in partnership with the Canadian Red Cross and the Weather Network has developed the programme "Expect the Unexpected" to prepare children for natural hazards, and emergency preparedness. State Farm Insurance also gives grants to non-profit organisations who are educating home buyers about catastrophe risk reduction, response preparedness, and disaster recovery. It is worth also mentioning the initiative of Aksigorta, a Turkish insuraner who have created a Fire and Earthquake Training Centre for school children to promote risk awareness and to learn how to protect themselves against these hazards.

7. Level of capital for insuring extreme events

One of the key issues in insuring extreme events is to know the amount of capital required by an insurer to provide protection against these events.

Insurers raise funds by collecting premiums and by raising equity capital from capital providers. These funds are invested in a number of assets, such as stocks and bonds. Holding equity capital makes it possible not only to guarantee the promise to pay claims, but also to reduce the cost of insurance by clients. Indeed, by purchasing less reinsurance to cover their losses, insurers reduce the price of coverage by clients. Insurers also hold equity capital to guarantee payment, in case claims are larger than expected. Equity capital can be raised by issuing stock in capital markets. It can be obtained from potential policyholders or other sources in the case of mutual insurers.

Faced with potentially huge losses due to natural catastrophes, traditional insurance companies encounter difficulties to finance coverage in the catastrophe line of business. The problem arises because the risk of natural catastrophe is not widely diversifiable in an insurance context where insurers supply coverage in well-defined business lines. Natural catastrophes tend to occur in selected areas of the globe, and many policyholders are affected at the same time, violating the assumption of statistical independence that makes the law of large numbers applicable. Thus, insurers are not able to disseminate the risk easily across the world, and cross-subsidisation among different lines of business is not feasible in a competitive market. To promise to pay for very large catastrophe losses, insurers must purchase reinsurance or hold equity capital. Yet, if the level of capital needed is higher, insurers must find capital from other sources to provide their clients with the same level of coverage. If the cost of this capital is high, the insurance premium that will be charged will be much more expensive.

As stressed by Cummins and Mahul (2009), the total cost of capital is the amount charged to compensate the insurer for bearing the risk. This cost is typically much larger in lines of insurance exposed to extreme events, where the actual loss can be many times larger than the expected loss. Therefore, capital costs are highest for policies that cover large losses with low probability of occurrence. In fact, the total cost of capital needs to be sufficient to provide a fair rate of return on the insurer's equity capital. This fair rate compensates the insurer's owners for placing their capital at risk in the insurance enterprise. To attract capital, the insurance industry must be sure its investors receive a rate of return comparable to what they could earn in alternative investments of comparable risk.

Holding equity capital is a risk retention plan for dealing with extreme events. Another possibility to increase capital is to buy reinsurance and to issue bonds, swaps and options. Such strategies can be considered as risk transfer strategies. In recent years, new risk transfer instruments have emerged involving the capital markets to complement traditional insurance and reinsurance. Bonds and options tied to catastrophic risk indices and weather-based index insurance are now available on some capital markets. These financial tools, also known as alternative risk transfer (ART) tools, provide hedge possibilities to corporations concerned with potential insolvency should a major natural disaster occur.[4] They also offer local as well as national governments financial protection after catastrophic events, if they have difficulty raising funds. Furthermore, they may attract investors as they increase diversification when mixed with other asset classes in a financial portfolio. However, as pointed out before, using risk transfer mechanisms can be expensive, especially for lines of insurance subject to catastrophe risk. These costs include reinsurance premiums as well as premiums paid for other ART instruments.

Naturally, the capital market can provide financial protection against natural disasters only if the risk involved can be properly quantified. Modelling the risks and vulnerabilities of regions subject to natural disaster is therefore a critical element of any solution involving the capital markets. But as it can be expected that these new tools will increasingly attract investors, it should lead to a deeper catastrophe risk quantification and assessment process and therefore should improve the mitigation of these risks and the prevention of potential related losses.

8. Conclusion

This chapter has focused on presenting the role of insurance in managing risks linked to extreme events. There is no doubt that the insurance industry will have an increasingly

4 We refer the readers to chapter 4 of this report for a deep analysis of the role of capital markets in providing coverage against extreme events.

important role to play in helping society to adapt and become more resilient to natural catastrophes and/or extreme events. Insurers can help in several ways: they can help in catastrophe modelling and in providing economic incentives to discourage, for instance, construction in high-risk areas. They can contribute to the collection of data on the cost of extreme events, to the promotion of risk awareness, of resilient reconstruction methods after losses and of adaptation solutions. They can also provide market-based incentives to prevention as well as risk retention and risk transfer mechanisms.

Predictions suggest that by 2025 more than 5.5 billion people worldwide will live in cities and a large proportion of them close to regions prone to extreme events. Without action, it is to be expected that powerful extreme events will affect several large urban areas in the coming decades. Governments and decision-makers should keep the dramatic events of 2011 in mind and wake up to the seriousness of the situation. The insurance industry is part of the solution for efficient catastrophic risk management programmes. Without a real effort from all stakeholders to develop and implement such solutions, it seems inevitable that the worst is yet to come.

References

Courbage, C., Liedtke, P. (2003) "Insurability, its limits and extensions", *Insurance Research and Practice*, 18(2): 44-49.

Cummins, D., Mahul, O. (2009) *Catastrophe Risk Financing in Developing Countries: Principles for Public Intervention*, Washington: World Bank Publications, The World Bank.

Herweijer, C., Ranger, R.,Ward, R. (2009) "Adaptation to Climate Change: Threats and Opportunities for the Insurance Industry", *The Geneva Papers on Risk and Insurance—Issues and Practice*, 34(3): 360-380.

Kunreuther, H., Meszaros, R., Hogarth, R., Spranca, M. (1995). "Ambiguity and underwriter decision processes", *Journal of Economic Behavior and Organization*, 26: 337-352.

Librairie Polytechnique (1885) *Encyclopédie des Travaux Publics*, Paris: Baudry et Cie.

Maynard, T. (2008), "Climate Change: Impacts on Insurers and How They Can Help With Adaptation and Mitigation", *The Geneva Papers on Risk and Insurance—Issues and Practice*, 33(1): 140-146, available at *http://genevaassociation.org/PDF/Geneva_papers_on_Risk_and_Insurance/GA2008_GP33(1)_Maynard.pdf*

Munich Re (2011) "Review of natural catastrophes in 2011: Earthquakes result in record loss year", Press Release, 4 January 2012, available at *http://www.munichre.com/en/media_relations/press_releases/2012/2012_01_04_press_release.aspx*

OECD (2011) *Risk Awareness, Capital Markets and Catastrophic Risks*, Policy Issues in Insurance, No. 14, Washington: OECD Publishing.

OECD (2005) *Catastrophic Risk and Insurance*, Policy Issues in Insurance, No. 8, Washington: OECD Publishing.

The Geneva Association (2009) *The insurance industry and climate change—Contribution to the global debate*, The Geneva Report No. 2, Geneva: The Geneva Association, available at *http://www.genevaassociation.org/PDF/Geneva_Reports/Geneva_report[2].pdf*

Swiss Re (2011) "Sigma – preliminary estimates for 2011: natural catastrophes and man-made disasters caused economic losses of USD 350 billion and cost insurers USD 108 billion", Press Release 15 December 2011, available at *http://www.swissre.com/media/news_releases/nr_20111215_preliminary_estimates_2011.html*

3. Public-private initiatives to cover extreme events

Alberto Monti

1. Introduction

The impressive series of extreme events that occurred in 2011 and their relevant economic impact brought the financial management of catastrophic risks once again at the forefront of the policy agenda of governments in several countries. These dramatic events constituted at the same time a test of the effectiveness and reliability of the existing prevention, protection and compensation mechanisms already in place, and the occasion to consider possible new strategies going forward.

Based on the Organisation for Economic Co-operation and Development (OECD) countries' experiences and internationally recommended good practices, this chapter is aimed at providing an overview and a brief discussion of the most relevant features of different public-private initiatives to cover extreme events. To this end, this chapter presents some of the institutional arrangements adopted in the OECD area regarding financial coverage against disaster risks, explaining the respective roles of the public and private sectors in providing insurance against the risk of catastrophic losses. This chapter also highlights and discusses certain key issues, presenting some of the lessons learned from the experiences of OECD member economies.

2. A public policy perspective on the financial management of extreme risks

The major catastrophes that occurred in 2011 clearly demonstrate that extreme events pose serious social and economic challenges not only to emerging economies, but to developed countries as well.

From the standpoint of governments, it shall be noted that the financial impact of extreme natural events and man-made disasters on private businesses and individuals can be significant, which in turn may cause large welfare losses, decreasing tax revenues and broad macroeconomic consequences, with cascading effects and systemic risk potential. Moreover, public budgets may be directly affected by the destruction, impairment or loss of use of public assets exposed to risk, including buildings and infrastructures. In the aftermath of a catastrophe, furthermore, experience shows that public authorities are under strong political pressure, or sometimes even under a legal duty, to provide assistance and compensation to injured parties. Planning ahead for the financial coverage of future disaster costs is, therefore, a necessary component of sound catastrophe risk management strategies in both emerging and developed economies worldwide.

In full recognition of the above, on 16 December 2010 the OECD issued a *Recommendation on Good Practices for Mitigating and Financing Catastrophic Risks* (OECD, 2010a), stating that governments should promote the development of efficient strategies for coping with large-scale catastrophes and that such strategies should be anchored in an integrated framework of risk assessment, risk perception, risk management and disaster response.

On that occasion the OECD Council, the highest political body of the organisation, expressly acknowledged that the costs associated with natural and man-made disasters need to be properly assessed and financially managed before a major loss occurs, and that this requires a proactive role to be taken by governments, in direct and continuous co-operation with the private sector. The OECD Recommendation stresses the importance of such a cooperation in all the different phases mentioned above, from preliminary risk evaluation to the economic coverage of disaster costs.

One first key aspect highlighted in the Recommendation concerns the need for creating a culture of risk assessment. The prime tasks in assessing risk are to measure the likelihood of possible disasters, the distribution of their consequences across different stakeholders and the uncertainties surrounding these estimates. For each type of risk and level of severity, governments should be able to quantify the costs they would have to bear under current programmes, as well as proposed strategies, should one or more of these disasters occur tomorrow. The Recommendation further clarifies that risk assessment should not be limited to the direct and immediate potential effects of a catastrophe (destroyed and damaged assets and affected victims), but also integrate secondary and indirect social and economic effects through geographical interdependencies and over time, which is indeed a much more complex and challenging technical exercise.

A related key point made by the OECD Recommendation is that governments and relevant public and private institutions would greatly benefit from the promotion of regional and international cooperation and synergies in the collection and sharing of data on exposures to large-scale disasters, as well as in the modelling of the nature of these risks.[1] In this regard, the development of harmonised taxonomies and categories should facilitate access to and comparison of information, data and statistics on catastrophe losses and possibly also on catastrophic risk exposures on a global scale.[2]

Increasing risk awareness and improving the quality of disaster risk reduction education efforts is yet another priority objective in the context of public-private initiatives to cope with extreme risks, since human-induced factors greatly contribute to direct and indirect costs of catastrophes. As discussed in the OECD *Policy Handbook on Natural Hazard Awareness and Disaster Risk Reduction Education* (OECD, 2010b) under the auspices of the OECD High-Level Advisory Board,[3] public awareness of natural hazards and

1 A very important public-private initiative in the field of catastrophic risk modelling is constituted by the Global Earthquake Model (GEM), also initiated by the OECD. The GEM Foundation is a public-private partnership that drives a collaborative effort aimed at developing and deploying tools and resources for earthquake risk assessment worldwide. Hundreds of organisations and individual experts, professionals and practitioners are working together on uniform global databases, methodologies, tools and open-source software; see *www.globalquakemodel.org*

2 On these issues, see also Monti and Tagliapietra (2009).

3 The High-Level Advisory Board—composed of experts from governments, private sector and academia—plays a leading role in identifying and discussing the major policy issues related to the financial management of large-scale catastrophes. It also performs advisory functions to the OECD

disaster risk reduction education constitute a foundation and prerequisite for effective catastrophic risk management strategies, since changes in patterns of human behaviour, perception and decision-making at all levels of government and society which can lead to a substantial reduction in disaster risk.[4]

From a public policy perspective, however, the development of *ex ante* measures to mitigate and foresee efficient coverage of the financial consequences of disasters, in partnership with the private sector, will need to take account of at least two potential challenges and obstacles. First, government relief, while often necessary, may somewhat deter in the long run *ex ante* action by potential victims of future catastrophic risks:[5] according to the OECD, governments' initiatives should, therefore, be designed to avoid as much as possible crowding out of individual initiatives and/or moral hazard. Second, it is politically more difficult to induce or require people to take potentially costly protective measures *ex ante* than to provide financial assistance following a disaster. The challenge here is to take a long-term view and promote the adoption of appropriate protective measures before a catastrophe occurs.[6]

The extensive research work and policy analysis conducted over the past 10 years by the OECD and its High-Level Advisory Board in this field show that risk financing and risk transfer tools, such as insurance, reinsurance and catastrophe-linked securities, can play a fundamental role in reducing the negative economic impacts of extreme risks and that it is, therefore, very important to fully recognise the policy implications of their use in the context of national or regional disaster risk management strategies.[7]

3. Public-private initiatives implemented in the OECD area

Recent experience in the OECD area indicates that following a disaster, governments regularly provide some degree of assistance and immediate aid to private businesses and individuals. Such emergency rescue and relief efforts are generally acknowledged as part of the basic responsibilities of the state and they are mainly aimed at saving lives and providing temporary assistance to the population hit by an extreme event. The costs of such measures are normally financed through tax revenues, but sometimes they are covered by dedicated disaster funds or other mechanisms.[8]

Secretary General and to the Insurance and Private Pensions Committee (IPPC) and the Committee on Financial Markets (CMF) in the drafting of guidelines, good practices, recommendations and principles; see *http://www.oecd.org/daf/fin/catrisks*

4 On these issues, see Michel-Kerjan and Slovic (eds.) (2010).

5 If one knows in advance that the government or international donors will provide ample financial assistance after hardship to those who were not protected, there will be less of an economic incentive for those in hazard-prone areas either to engage in loss reduction measures prior to a disaster and/or to purchase adequate insurance coverage, when available; see OECD (2010a).

6 See Kunreuther and Michel-Kerjan (2009).

7 See OECD (2011) offering an in-depth analysis of the financial and legal implications of the possible use of cat-linked securities in the financial management of large-scale risks, including a set of recommendations for governments; OECD (2008) containing three reports focusing on: different institutional approaches to the financial management of large-scale catastrophes in selected OECD and non-OECD countries, the role of risk mitigation and insurance in reducing the impact of natural disasters, and the importance of strategic leadership in the management of non-conventional crises. See also OECD (2005a, 2005b); OECD (2004); and Monti (2003).

8 In this regard, it is interesting to note that in Mexico, emergency relief costs and also certain relevant government exposures to public assets and infrastructure disaster losses are funded by FONDEN, a

As concerns reconstruction costs and the compensation of property damages and economic losses suffered by those affected by a disaster, the situation differs across OECD member countries. In some states, the government directly provides, to a greater or lesser extent, compensation to property owners *ex post* by means of either permanent structural arrangements, such as compensation funds and public insurance schemes or *ad hoc* disbursement of public funds on a discretionary basis.[9] In others, the costs of repair or replacement of destroyed assets fall on private owners of the damaged properties, and institutional mechanisms to stimulate private insurance coverage of these risks are in place.

Despite significant differences in the institutional solutions adopted,[10] OECD countries' policies in the field of financial management of large-scale disaster risks are mainly aimed at reducing the negative impact of disaster losses on the population and the economy, and to facilitate and improve relief, rehabilitation and reconstruction efforts. Shared policy objectives in this area expressly include the enhancement of disaster risk prevention, reduction, mitigation and response strategies, and the reduction of government exposure to catastrophe risk by means of public-private cooperation schemes involving the private insurance sector. The opportunity to involve the insurance and reinsurance industries in the financial management of disaster risks is based on the observation that in the OECD area, the private insurance sector has developed the requisite technical expertise for providing proper risk assessment and risk allocation mechanisms, expedite loss adjustment services, and contractual incentives to reduce risk exposure, in exchange for wider coverage and/or lower premiums.

3.1. Different forms of public sector role in disaster insurance schemes

In consideration of the peculiar insurability problems posed by extreme risks, as discussed in the previous chapters of this Report, some OECD governments have entered into partnerships with the private insurance sector, with the policy objective of making disaster insurance available to the general public at affordable rates and/or ensuring that private and sometimes public assets exposed to risk are duly covered by insurance. To this end, special institutional arrangements aimed at the explicit coordination of public and private actions have been set up to deal with losses caused by natural catastrophes and man-made disasters.

The existing public-private initiatives to cover catastrophic risks in the OECD area are numerous and their technical features quite diverse. In certain countries, governments have decided to offer special reinsurance arrangements, dedicated lending facilities or other forms of backstop or guarantees to limit private sector exposure in case of catastrophic losses. With the aim to provide an analytical framework, it was noted[11] that where OECD governments have elected to make financial commitments to cover the costs of extreme events, they have acted, directly or through special purpose entities, as:

dedicated catastrophe reserve fund, supplemented by market-based risk transfer tools, including cat-linked securities. See, most recently Michel-Kerjan *et al.* (2011) and OECD (2011).

9 In a number of countries, pursuant to the principle of solidarity, the mutualisation of losses arising out of disaster events is perceived as a fundamental right of the citizens, and the role of the government in the compensation phase is, therefore, considered essential. This is the case, for instance, in Belgium, France, Italy and Spain. See OECD (2008).

10 See Monti (2008 and 2009).

11 See Monti (2008).

1. **Primary insurer** (such as in Spain, New Zealand for earthquake risks and Iceland): The government acts as an insurer by providing insurance and responding to claims, either to the fullest or up to a certain limit. Sometimes the private insurance sector contributes to the scheme by providing some operational capabilities (such as marketing and premium collection).
2. **Reinsurer of last resort** (such as in France, through the *Caisse Centrale de Réassurance*, for all catastrophic risks, and in Japan, through the Japan Earthquake Reinsurance Co., Ltd. for seismic risks): The government protects the insurance sector by offering special reinsurance arrangements. Government-sponsored reinsurance programmes may be mandatory or optional for primary carriers.
3. **Backstop liquidity provider** (such as in Australia and in the U.K. for terrorism risks): The government provides liquidity to the insurers incurring payout burdens or losses due to a catastrophic event by means of a pre-arranged contingent loan facility.
4. **Guarantor** (such as in Spain and New Zealand for earthquake risks, France and Iceland): The government guarantees that any special purpose entity, pool or fund created to cover catastrophic risks will meet all its obligations.

Special risk-sharing agreements between the private and public sectors, mixing the above features, have also been implemented in Belgium for natural catastrophes and terrorism (through the *Caisse nationale des calamités* and the Terrorism Insurance & Reinsurance Pool), in Germany (Extremus AG) and in the United States (under the Terrorism Risk Insurance Act of 2002 (TRIA) and its extensions) for terrorism risks.

Concerning the different types of public sector *ex ante* financial commitments in disaster risk transfer, it shall also be noted that:

- The policy choice to provide primary insurance coverage against disaster risks may be dictated by the fact that the private insurance sector is unwilling and/or unable to provide any coverage. Private sector operational capacity, if available and cost-convenient, may be used to perform such functions as marketing, premium collection and claims handling.
- The option to provide special reinsurance arrangements is aimed at limiting private sector exposure to peak risks. This solution may be justified if the primary insurance carriers are able to retain a portion of the risk, but there is not enough reinsurance capacity on the private market to provide the required stop loss arrangements. The provision of such a limitation to private sector exposure may also be part of an institutional arrangement in which mandatory offer, purchase, or extension of disaster risk coverage was introduced by law. In this respect, this option may be aimed at protecting the insurers' solvency and, therefore, the stability of the whole system.
- The choice to act as backstop liquidity provider, for instance by offering a prearranged contingent loan facility to insurance companies writing disaster risks, is aimed at helping insurers to smooth catastrophe losses over time. In other words, in this scenario private insurance and reinsurance companies retain the ultimate risk, but they benefit from a more convenient inter-temporal flow of funds. This allows private sector participants to gradually adjust the pricing of coverage over time and alleviates the financial problems associated with the inter-temporal mismatch between the size of annual premiums and the size of the annual expected losses.

3.2. The mandatory vs. voluntary nature of disaster insurance schemes

OECD experience demonstrates that the government's decision to play an active role in public-private disaster risk transfer schemes by making an *ex ante* commitment of financial resources is often linked with the resolution to introduce a mandatory or quasi-mandatory catastrophe insurance regime. However, it is extremely important to clarify the actual meaning of "mandatory" under a given institutional arrangement.[12]

Some countries have made the purchase of catastrophe insurance coverage mandatory: this is the case, for instance, in Turkey (earthquake) and Iceland. The purchase of fire and natural disaster insurance is also mandatory in the Swiss cantons of Schwyz, Uri and Obwalden.

In Turkey, in particular, following the major earthquakes that occurred in 1999 in the Marmara Region and Duzce, earthquake insurance was made compulsory primarily for dwellings through a special programme. In September 2000, the Turkish Catastrophe Insurance Pool (TCIP) was set up—in cooperation with the World Bank and in fulfilment of a government decree law—as a separate state-owned legal entity to provide such compulsory insurance.[13] Pursuant to the applicable provisions of law, the taking out of earthquake insurance was made mandatory for all residential buildings that fall within municipality boundaries starting from 27 September 2000. Industrial and commercial risks as well as residential buildings in small villages (with no municipality established) can be insured on a voluntary basis.[14] Earthquake insurance premiums are ceded to the TCIP, which is managed by the Natural Disasters Insurance Council, DASK in the Turkish abbreviation. Local insurance companies act as distributors of the TCIP policies and coverage in excess of the TCIP coverage can be obtained on a voluntary basis from private insurance providers. Basically, the TCIP operates as a catastrophe risk transfer and risk financing facility and it continues to cede a large amount of its risk to international reinsurance markets until sufficient financial resources are accumulated.

Other OECD countries, instead, have simply required insurance companies to make catastrophe insurance available, by introducing a mandatory offer of coverage that can be declined by the policyholder: this is how, for instance, the Japanese and the Californian earthquake schemes work. A similar approach also characterises TRIA and its extensions with regard to terrorism risk insurance in the U.S.

In California, for instance, insurers that sell residential property insurance—including coverage for homeowners, condominium owners, mobile-home owners, and renters—are mandated by the law to offer earthquake coverage to their policyholders. To this purpose, insurance companies can join the California Earthquake Authority ("CEA") and offer the CEA's residential earthquake policies, or they can manage the risk themselves. At present, most of the companies that sell residential property insurance in California decided to become CEA-participating companies. It shall be noted that the state offers no guarantee:

12 See Monti (2009).

13 In addition to the legal framework of TCIP, a new code on building inspection was enacted by the Parliament. The TCIP is managed through the TCIP Management Board consisting of members from public and private sectors and academic community. The Management Board consists of representatives of Prime Ministry, Under-Secretariat of the Treasury, Ministry of Public Works, Capital Market Board, Insurers Association, Operational Manager, and an earthquake scientist.

14 The compulsory earthquake insurance is a stand-alone product sold separately from fire (or homeowner's) insurance. It covers building damages for the following risks: earthquake; fire related to earthquake; explosion related to earthquake; and landslide related to earthquake.

therefore, if losses from an earthquake drain the established fund, the CEA may run out of business and claims will be paid out on a pro-rated basis.

In Japan, earthquake insurance cannot be purchased as a stand-alone policy since it is arranged by law as an optional rider to fire insurance which covers buildings for residential use and/or personal property. The Japan Earthquake Reinsurance Co., Ltd. ("JER") was established in 1966 as the only company permitted to exclusively handle reinsurance for earthquake insurance on dwelling risks.[15] Since earthquake coverage is relatively expensive and its purchase is not mandatory, however, the penetration level remains quite low. The scope of earthquake coverage provided by JER includes loss of or damage to buildings for residential use and/or personal property through fire, destruction, burial or flooding caused directly or indirectly by any earthquake or volcanic eruption, or resulting tsunami. Under the Japanese earthquake reinsurance programme, therefore, primary carriers sell earthquake coverage with large deductibles on the voluntary market—as mentioned, insurers are obliged to offer the optional earthquake extension with all residential fire insurance policies, but policyholders may decide not to purchase it—and then fully reinsure their risk with JER, which, in turn, retrocedes part of the risk to the Japanese government, and part of it to the private insurance market.[16]

In a number of countries, moreover, fire or other first party insurance policies are marketed on a voluntary basis, but insurance companies are required by law to include coverage for catastrophic risks in such policies. This is the case, for instance, in Australia (terrorism), Belgium, France (natural catastrophes, terrorism and technological disasters), New Zealand (earthquake), Norway, Spain and Switzerland (with the exception of the cantons of Schwyz, Uri and Obwalden, where fire and natural perils coverage, as said, is mandatory).

In France, for example, as a result of a series of legislative interventions, private insurance companies may not exclude from first party coverage losses arising out of: (a) natural catastrophes, (b) technological disasters, or (c) terrorism. While the market for first party policies (such as fire policies) is, as a general rule, voluntary in France, most people do in fact take up insurance, especially if they own or rent premises.[17] Concerning natural perils, pursuant to applicable provisions of the French Insurance Code, insurance contracts, issued to any natural or legal persons other than the state in order to insure against damage caused by fire or any other damage to property located in France as well as damage to hulls of motor vehicles, must also cover against the effects of natural disasters and subsidence of land due to underground cavities or due to marl pits on property covered by the insurance contracts. In addition, when the insured is covered for business interruption, the cover must be extended to the effects of natural disasters in accordance with the terms of the corresponding contract. This regime, established by law in 1982 and forming the basis of the French National Disaster Insurance Scheme (CAT NAT), does not refer to an exhaustive list of natural perils covered, nor does it contain a complete list of exclusions.

15 For about 45 years since then, JER has been underwriting the dwelling risk of earthquakes in Japan in partnership with the Japanese government and non-life insurance companies.

16 The aggregate limit of indemnity for earthquake insurance liabilities (JPY5,500bn since 1 April 2009) is shared by the private and public sectors according to a complex layered mechanism. Pursuant to the applicable provisions of the Earthquake Insurance Act, where earthquake insurance liabilities for one event exceed the indemnity cap, residential policyholders' claims are reduced proportionately.

17 Household insurance coverage is mandatory for tenants under French law, while most lenders require home owners to show proof of adequate insurance in order to obtain a loan.

The 1982 law merely refers to the notion of "uninsurable damage"; in particular, the Insurance Code states that uninsurable direct material damage, caused by the abnormal intensity of a natural agent, when normal measures have been taken to avoid such damage have been unable to prevent the occurrence thereof or could not be taken, shall be deemed to be a natural disaster. In any event, the existence of natural disaster must be expressly declared by inter-ministerial decree which shall determine the areas and the periods of the occurrence of the disaster and the nature of the damage.[18]

In Spain, catastrophic risks coverage is carried out by the *Consorcio de Compensación de Seguros*, a public non-profit institution attached to the Ministry of Economy and Finance.[19] The *Consorcio* has its own assets and liabilities, separate from those of the state, and its activity is governed by private law. The aim of the *Consorcio* is to indemnify claims made as a result of extraordinary events, such as natural disasters or other events with heavy social repercussions, that occur in Spain and cause injuries and damage to people and assets in Spain, whenever any of the following conditions are met: (a) the extraordinary risk is not specifically and explicitly covered by another insurance policy; and (b) the extraordinary risk is covered by another insurance policy but the company that issued this policy cannot meet its obligations. The risks included in the Spanish system for the coverage of extraordinary risks in practice are not assumed by insurance companies, even if the system legal rules permit insurance companies to cover these types of risks. The *Consorcio*, in a subsidiary manner, assumes these risks; the insurance companies underwrite and manage the policies, with the compulsory extension of coverage attached, and the *Consorcio* collects surcharges. Claims, loss adjustments, and indemnifications are managed by the *Consorcio*.

In New Zealand, all residential property owners who voluntarily buy fire insurance from private insurance companies automatically acquire EQCover, the seismic disaster insurance cover provided by the Earthquake Commission (EQC), a Crown Entity wholly owned by the government of New Zealand and controlled by a board of commissioners. EQC administers the Natural Disaster Fund and the government guarantees that this fund will meet all its obligations. EQCover premiums are added to the cost of the fire insurance and passed on to EQC by the insurance company. EQC's administration of the natural disaster insurance scheme involves: collecting premiums via insurance companies; processing and meeting claims by insured people; administering a disaster fund; investing the fund in accordance with government directions; organising reinsurance as a potential supplement to the fund; and accounting to its shareholder (the government). EQC also

18 The CAT NAT scheme works effectively due to the fact that the *Caisse Centrale de Réassurance* (CCR), a state-owned company established in 1946, entered into an agreement with the authorities that allows it to offer reinsurance cover with a government guarantee in the field of natural disasters. CCR does not have a monopoly in natural disaster reinsurance: primary carriers, therefore, are free to seek coverage from the reinsurer of their choice, and may even take the risk of not purchasing reinsurance. In any event, CCR appears to be the only company within its sector of activity that offers a whole range of proportional and non-proportional reinsurance solutions with unlimited cover.

19 Set up in 1941 as a provisional body to face the needs for indemnities resulting from the Civil War (1936-1939), the Spanish *Consorcio de Compensación de Seguros* was given its permanent status from 1954. After that date, the activity of the Consorcio focused on the coverage of the so-called extraordinary risks and it began to play a central role in the related indemnity system. Since the approval of its Charter in 1990, which came into force in 1991, the *Consorcio* lost its legal monopoly for covering extraordinary risks in Spain and it is no longer a self-running body of the Ministry of Economy and Finance, but a state-owned company—currently a public business entity—with full powers to act.

encourages and funds research about matters relevant to natural disaster damage and it educates and otherwise informs people about what can be done to prevent and mitigate damage caused by natural disasters.

Finally, the mandatory component of the scheme may concern the participation of private insurance companies in special pooling and/or reinsurance arrangements, such as the Natural Perils Pool in Norway.

3.3. Other features characterising public-private initiatives

The institutional arrangements set up in OECD countries cover different types of perils. Some of them have a broad scope of application, encompassing coverage for a wide range of catastrophic risks—the Spanish *Consorcio de Compensación de Seguros* offers a good example of this approach, covering both natural catastrophes and socio-political events, including terrorist acts.[20] Others focus instead on single perils or categories of perils (such as natural calamities, earthquake, terrorist acts, technological accidents, etc.).

In France, as mentioned, there are three different schemes covering natural catastrophes, terrorist incidents and industrial accidents respectively. In Belgium two schemes were set up to cover certain natural perils (i.e., earthquake, flood, storm, landslide and ground subsidence) and terrorism risks respectively. In Iceland, insurance coverage is mandatory for earthquake, volcanic eruption, snow avalanches, landslides and floods. In Japan, the public-private initiative covers earthquakes, volcanic eruptions and resulting tsunamis. The Mexican FONDEN covers geological risks (earthquake; volcanic eruption; avalanche; tidal wave; landslide), hydro-meteorological risks (atypical drought; cyclone; extreme rains; snowfall and hailstorm; atypical floods; tornado) and forest fires. In New Zealand the scheme covers: earthquake, natural landslip, volcanic eruption, hydro-thermal activity, tsunamis (in the case of residential land, a storm or flood; fire caused by any of these). The Norwegian pool covers losses caused by landslide, storm, flood, earthquake and volcanic eruption. In Switzerland the coverage of flood, inundation, windstorm, hail, avalanche, snow pressure, rock and stone fall, and landslide (but not earthquake) has been included by operation of law in fire insurance for buildings and chattels. In Turkey, although the original design of TCIP envisaged a multi-peril coverage, it currently provides only compulsory earthquake insurance coverage.

A number of schemes, moreover, require an "official declaration" to trigger coverage: this is the case under the schemes implemented in the Netherlands (Royal Decree) and in Denmark (Danish Storm Council), the Mexican FONDEN and the French CAT NAT scheme. This has also been the case in Spain until 1986, when the requirement for an official declaration was removed. While the official declaration requirement has the

20 The perils covered under the Spanish system for the coverage of "extraordinary risks" are listed in the applicable regulation and include: extraordinary floods, earthquakes, seaquakes, volcanic eruptions, atypical cyclonic storms (tornadoes and gusts of wind above 135 km/h included) and fall of sidereal bodies and meteorites. It should be noted that protection against extraordinary risks is entirely separate from protection against other risks provided for in the policy. In other words, the coverage of extraordinary risks protects the same property or persons for at least the same amount insured. Coverage is triggered by any loss from any 'extraordinary risk'. This coverage is qualitative, not quantitative (there are no minimum or maximum damage amount requirements). The maximum amount of compensation depends on the amount insured in the policy base. With respect to property damage, the indemnity paid by the *Consorcio* covers material losses, regarded as being the destruction or deterioration of the property insured, and direct losses, so damage caused directly by the event.

advantage of making incontestable that a certain event is covered by the scheme, the decision-making process may be time-consuming and politically biased.

While multi-peril disaster insurance allows for broader coverage, it also raises complex issues related to underwriting and pricing. Setting premium rates adequate to cover all the expected costs of disaster losses caused by different perils, in fact, requires sophisticated determinations. The rate-setting process for setting flood insurance rates, for instance, is different from what is needed for the coverage of other perils. In some countries, multi-peril coverage has been introduced to achieve a higher level of risk pooling and some degree of cross-subsidisation. However, countries with very high exposures to one main peril (such as earthquake) have often chosen to focus on a single-peril type of scheme.

The various OECD institutional solutions, furthermore, differ in terms of type of lines of insurance and losses covered. Most of the schemes provide compensation for direct property damage, but the nature of the property covered may vary (commercial vs. residential properties; private properties vs. public properties and infrastructures, etc.). In France, the CAT NAT scheme covers commercial and residential property damages as well as business interruption losses (but not damages to public property owned by the state). The earthquake scheme in Turkey is also limited to registered residential properties in municipal areas. The coverage offered by the Spanish *Consorcio*, on the other hand, includes residential and industrial property damages, business interruption losses, as well as personal injuries and death.[21] The public-private scheme implemented in New Zealand covers direct losses to residential dwellings (self-contained premises used as a home, including apartments), most personal property (excluding some types, e.g. motor vehicles and art) and the land immediately around the dwelling. The scope of application of the Japanese earthquake insurance mechanism is also limited to residential buildings and household property.

4. Conclusions and lessons learned

Looking at the current situation in OECD member economies and in line with internationally recommended good practices, it can be affirmed that the development and maintenance of efficient and effective strategies for the financial management of extreme risks require a joint and proactive effort of both the public and private sectors.

Setting up the most appropriate public-private cooperation scheme at country or regional level is, however, a difficult task to perform, since several variables must be carefully considered and potentially diverging interests must be aligned.

Lessons learned from experience in the OECD area indicate that any governmental strategy for coping with large-scale catastrophes in partnership with the private insurance and reinsurance sectors should be anchored in an integrated framework of risk assessment, risk perception, risk management and disaster response,[22] and it should be based on a sound evaluation of at least the following elements:

21 In Spain, the lines of insurance that must include coverage for extraordinary risk are the following: fire and natural events; land vehicles (vehicle damage, not civil liability); railways vehicles; other damages produced to goods (robbery, plate glass, machinery breakdown, electronics equipment and computers); business interruption; and life. Accident insurance is also included, even if contracted additionally to another type of insurance, as life or motor vehicles, or within the framework of a pension plan.

22 See OECD (2010a).

1. the vulnerability and exposure of the country to natural and man-made hazards, and the risk differentials across the country;
2. the extent of public sector financial resources available for the coverage of emergency relief costs and other disaster losses, including the costs of reconstruction of private and public assets damaged by the extreme event;
3. the policy objectives to be pursued by the strategy (e.g., obtaining the necessary liquidity to cover emergency relief and response costs; protecting public assets and infrastructure exposed to risk; providing full protection to private assets exposed to risk; making coverage available to individuals and businesses; introducing incentives to invest in cost-effective disaster risk prevention and mitigation measures);
4. the financial capacity of the local insurance industry, including its capitalisation, solvency, access to international reinsurance, and access to global capital market instruments; and
5. the operational capacity of the insurance industry to perform key functions such as marketing of policies, collection of premiums, claims handling and loss adjusting. The resilience of private insurance sector participants—i.e., their ability to withstand a disaster event from an operational perspective—must also be assessed, taking into account existing crisis management and business continuity plans.

In the context of public-private initiatives to cover extreme risks, whatever institutional form they may take, all relevant stakeholders should be made clearly aware of their respective roles, since a clear and transparent allocation of risks and responsibilities among public authorities, private firms and individuals is a key component of an effective institutional arrangement, and a driver to the success of any catastrophe risk insurance programme.

After the major catastrophic events that occurred in the recent years, several OECD countries have started an in-depth review of their current policies and arrangements, having acknowledged that there is ample room to learn from past experience, with a view to improving further the synergies between public and private investments in this field.

References

Kunreuther, H. and Michel-Kerjan, E. (2009) *At War with the Weather,* Cambridge, MA.: MIT Press.

Michel-Kerjan, E. and Slovic, P. (eds.) (2010) *The Irrational Economist*, New York: Public Affairs Press.

Michel-Kerjan, E., Zelenko, I., Cardenas, V. and Turgel, D. (2011) *Catastrophe Financing for Governments: Learning from the 2009-2012 MultiCat Program in Mexico*, OECD Working Papers on Finance, Insurance and Private Pensions No. 9, Paris: OECD Publishing.

Monti A. (2009) "Climate Change and Weather-related Disasters: What Role for Insurance, Reinsurance and Financial Sectors?", in *Hastings College of the Law West-Northwest Journal of Environmental Law & Policy*, 15: 151-172.

Monti A. (2008) "Policy Approaches to the Financial Management of Large-Scale Disasters", in *Financial Management of Large-Scale Catastrophes*, Policy Issues in Insurance No. 12, Paris: OECD Publishing.

Monti A. (2003) *Environmental risks and insurance: A comparative analysis of the role of insurance in the management of environment-related risks*, Policy Issues in Insurance No. 6, Paris: OECD Publishing.

Monti A. and Tagliapietra C. (2009) *Tracking insurance industry exposures to CAT risks and quantifying insured and economic losses in the aftermath of disaster events: a comparative survey*, presented at the OECD Second Conference on the Financial Management of Large-Scale Catastrophes, Bangkok, 24-25 September 2009, available at *http://www.oecd.org/daf/fin/catrisks*

OECD (2012) Global Earthquake Model (GEM) Foundation, see *http://www.oecd.org/document/24/0,3343,en_2649_34319_35997400_1_1_1_1,00.html*

OECD (2011) "Catastrophe-linked Securities and Capital Markets", in *Risk Awareness, Capital Markets and Catastrophic Risks*, Policy Issues in Insurance No. 14, Paris: OECD Publishing.

OECD (2010a) *Recommendation of the Council on Good Practices for Mitigating and Financing Catastrophic Risks*, available at *http://www.oecd.org/daf/fin/catrisks*

OECD (2010b) *Policy Handbook on Natural Hazard Awareness and Disaster Risk Reduction Education*, available at *http://www.oecd.org/daf/fin/catrisks*

OECD (2008) *Financial Management of Large-Scale Catastrophes*, Policy Issues in Insurance No. 12, Paris: OECD Publishing.

OECD (2005a) *Catastrophic Risk and Insurance*, Paris: OECD Publishing

OECD (2005b) *Terrorism Risk Insurance in OECD Countries*, Policy Issues in Insurance No. 9, Paris: OECD Publishing.

OECD (2004) *Large-Scale Disasters: Lessons Learned*, Paris: OECD Publishing.

4. CAT bonds and other risk-linked securities: product design and evolution of the market

J. David Cummins

1. Introduction

This chapter analyses risk-linked securities as sources of risk capital for the insurance and reinsurance industries.[1] Risk-linked securities are innovative financing devices that enable insurance risk to be sold in capital markets, raising funds that insurers and reinsurers can use to pay claims arising from mega-catastrophes and other loss events. The most prominent type of risk-linked security is the catastrophic risk (CAT) bond, which is a fully collateralised instrument that pays off on the occurrence of a defined catastrophic event. CAT bonds and other risk-linked securities are important because they have the ability to access the capital markets to provide capacity for insurance and reinsurance markets. The CAT bond market has expanded significantly in recent years and now seems to have reached critical mass. Although the CAT bond market is small in comparison with the overall reinsurance market, it is of significant size in comparison with the property-catastrophe reinsurance market. Some industry experts observe that non-traditional risk financing instruments, including CAT bonds, industry loss warranties (ILWs), and sidecars, now represent a substantial component of the property-catastrophe retrocession market.

This chapter begins by discussing the design of CAT bonds and other risk-linked securities. The discussion then turns to the evolution of the risk-linked securities market and an evaluation of the current state of the market. The scope of the chapter is limited primarily to securitisation of catastrophic property-casualty risks. However, there also are rapidly developing markets in automobile and other types of non-catastrophe insurance securitisations, as well as life insurance securitisations, which are discussed in Cowley and Cummins (2005) and Cummins and Barrieu (2012).

2. The structure of risk-linked securities

This section considers the structure of CAT bonds and other risk-linked securities that have been used to raise risk capital for property-casualty risks. The discussion focuses primarily on CAT bonds but also considers other innovative risk-financing solutions. Included in the latter category are some investment structures that are not necessarily securities in the sense of being tradable financial instruments but are innovative approaches whereby insurers and reinsurers can access capital markets to supplement traditional reinsurance.

1 This chapter is based on Annex 9 of Cummins and Mahul (2008). It has been revised and updated for this report. Some of the tables and figures also appear in Cummins and Barrieu (2012).

2.1. Risk-linked securities: early developments

Following Hurricane Andrew in 1992, efforts began to access securities markets directly as a mechanism for financing future catastrophic events. The first contracts were launched by the Chicago Board of Trade (CBOT), which introduced catastrophe futures in 1992 and later introduced catastrophe put and call options. The options were based on aggregate catastrophe loss indexes compiled by Property Claims Services (PCS), an insurance industry statistical agent.[2] The contracts were later withdrawn due to lack of trading volume. In 1997, the Bermuda Commodities Exchange (BCE) also attempted to develop a market in catastrophe options, but the contracts were withdrawn within two years as a result of lack of trading.

Insurers had little interest in the CBOT and BCE contracts for various reasons, including the thinness of the market, possible counterparty risk on the occurrence of a major catastrophe, and the potential for disrupting long-term relationships with reinsurers. Another concern with the option contracts was the possibility of excessive basis risk—the risk that payoffs under the contracts would be insufficiently correlated with insurer losses. A study by Cummins, Lalonde, and Phillips (2004) confirms that basis risk was a legitimate concern.

Another early attempt at securitisation involved contingent notes known as "Act of God" bonds. In 1995, Nationwide issued US$400 million in contingent notes through a special trust, Nationwide Contingent Surplus Note (CSN) Trust. Proceeds from the sale of the bonds were invested in 10-year Treasury securities, and investors were provided with a coupon payment equal to 220 basis points over Treasuries. Embedded in these contingent capital notes was a "substitutability" option for Nationwide. Given a pre-specified event that depleted Nationwide's equity capital, Nationwide could substitute up to US$400 million of surplus notes for the Treasuries in the Trust at any time during a 10-year period for any "business reason," with the surplus notes carrying a coupon of 9.22 per cent.[3] Although two other insurers issued similar notes, this type of structure did not achieve a significant segregation of Nationwide's liabilities, leaving investors exposed to the general business risk of the insurer and to the risk that Nationwide might default on the notes. In addition, unlike CAT bonds, the withdrawal of funds from the trust would create the obligation for Nationwide eventually to repay the Trust. Consequently, contingent notes have not emerged as a major solution to the risk-financing problem.

2.2. Catastrophe Futures and Options

In 2007 three separate exchanges, the Chicago Mercantile Exchange (CME), the Insurance Futures Exchange (IFEX), and the New York Mercantile Exchange (NYMEX), introduced futures-and-options contracts on U.S. hurricane risk. The introduction of the contracts was motivated by the 2005 U.S. hurricane season, which revealed the limitations on the capacity of insurance and reinsurance markets. As of mid-2011, the NYMEX contracts had been withdrawn but the CME and IFEX contracts are still listed. To date,

2 Contracts were available based on a national index, five regional indexes, and three state indexes, for California, Florida, and Texas. For further discussion, see Cummins (2005) and Cummins and Weiss (2009).

3 Surplus notes are debt securities, issued by mutual insurance companies, that regulators treat as equity capital for statutory accounting purposes. The issuance of such notes requires regulatory approval.

Table 1: Principal characteristics of catastrophe futures and options

Exchange	IFEX	CME	CBOT PCS
Type of contract	Futures	Futures and options	Options
Loss index	PCS	Carvill Hurricane Index (parametric) (CHI)	PCS
Index definition	PCS loss	Index is function of storm wind speed/radius	PCS Loss/100M
Event	U.S. tropical wind	U.S. hurricane	U.S. insured property losses
Geographical region	50 U.S. states, DC, Puerto Rico, Virgin Islands; Gulf Coast, Florida	Six U.S. regions	National, 5 regions, 3 states
Trigger	Annual aggregate losses from 1st, 2nd, 3rd, or 4th event	Aggregate loss	Aggregate loss in geographical area
Trigger products	US$10, US$20, US$30, US$40, and US$50 billion losses	(1) numbered event, (2) seasonal, (3) seasonal maximum event	Strikes in multiples of 5 points
Trigger type	Binary	Aggregate/American	Aggregate/European
Contract payoff	US$10,000*If[I>T,1,0]	US$1,000*CHI	US$200 per index point
Maximum payout	US$10,000 per option	No maximum	No maximum
Contract period	Annual	(1) landfall + 2 days (2) 1/6 to 30/11 + 2 days (3) 1/6 to 2 days after 30/11	Calendar quarter
Contract expiration	18 months after end of contract period	(1) 2 days after landfall (2) 30/11 + 2 days (3) 30/11 + 2 days	6 or 12 month development period
Launch date	21/9/2007	12/3/2007	9/1995

Note: IFEX = Insurance Futures Exchange, CME = Chicago Mercantile Exchange, CBOT = Chicago Board of Trade, PCS = Property Claims Services. I = index, T = trigger.
Sources: Websites of IFEX, NYMEX, CME, and American Academy of Actuaries (1999).

there has been minimal trading in the new contracts, but there is potential for future growth. The characteristics of the futures and options contracts launched in 2007 are shown in Table 1, which also shows information on the CBOT-PCS options for purposes of comparison. There are some significant differences in design features among the three types of contracts shown in the table.

The IFEX Event Loss Futures (ELF) contracts are unique among insurance derivative contracts offered to date because they are designed to mimic ILWs and therefore can be used to hedge ILW risk.[4] The contracts are designed to pay off on PCS insured catastrophe loss indices, for U.S. tropical windstorm losses in defined geographical regions. A contract is available covering the 50 U.S. states, the District of Columbia, Puerto Rico, and the Virgin Islands, and contracts are also available covering Florida and the Gulf Coast. The contacts currently available are 1st, 2nd, 3rd, and 4th event contracts, with triggers of US$10, US$20, US$30, US$40, and US$50 billion. For example, suppose an insurer buys a 1st event contract with a trigger of US$10 billion. The contracts are binary, paralleling the most common type of ILW contract, meaning that the contract would pay US$10,000 for the 1st event that breached the US$10 billion limit as measured by PCS insured losses. The contract coverage period is the calendar year.5 Because of the binary feature and the geographical areas covered, the IFEX futures are subject to substantial basis risk.

The CME contracts differ from the IFEX contracts in that they are not binary but instead are valued at US$X times the value of the triggering index. The CME offers six U.S. regional contracts, which pay off on a parametric index developed by Carvill Corporation (Carvill, 2007). CME contracts are available, covering numbered events (e.g., 1st event, 2nd event), seasonal accumulations, and accumulations from seasonal maximum events. The CME contracts potentially have less basis risk than the IFEX contracts because more regional contracts are available. 6 However, the CME adds a source of basis risk by using a parametric index.

It is instructive to compare the insurance futures and options contracts introduced in 2007 with the earlier CBOT-PCS options. The CBOT options were similar to the IFEX options in using PCS index triggers, and they were similar to the CME contracts in offering regional as well as national contracts. The CBOT contracts differed from the more recent contracts in that they primarily covered losses in calendar quarters rather than annually or during the hurricane season and covered losses from all sources, including earthquakes.

Except for the fact that IFEX contracts parallel ILWs and the current contracts exclude terrorism and earthquakes, there seem few design features in the current contracts that predict that they will succeed relative to the CBOT-PCS contracts. The hope for success hinges on the market's being more sophisticated now than it was during the 1990s and on the existence of a much larger volume of CAT bonds/ILWs that could be hedged using options. The futures/options market seems to be affected by an unfortunate "Catch 22," i.e., potential hedgers are unwilling to trade until liquidity develops but no liquidity will develop until sufficient numbers of hedgers begin to trade. Uncertainties regarding the

4 Although ELFs generally resemble ILWs, they do not contain an indemnity trigger, and traders do not need to have underwriting exposure in order to utilise the contracts.

5 Because of the "1st event-binary" feature, the contract would not pay off if two catastrophes occurred, one causing damages of US$5 billion and the next causing damages of US$6 billion. If the 1st event contract is triggered, the insurer could obtain additional protection by purchasing 2nd event contracts.

6 The NYMEX contracts have an annual coverage period, while the CME contracts cover the hurricane season (1 June through 30 November).

accounting, regulatory, and rating agency treatment of the contracts also may impede market development. Although such problems have been overcome in the past with respect to options on other underlying factors, such as non-catastrophe weather risk; whether the catastrophe derivatives market will succeed remains unclear.

2.3. Catastrophic Risk (CAT) Bonds

The securitised structure that has achieved the greatest degree of success is the CAT bond—modelled on asset-backed-security transactions that have been executed for a wide variety of financial assets, including mortgage loans, automobile loans, aircraft leases, and student loans. CAT bonds are part of a broader class of assets known as *event-linked bonds*, which pay off on the occurrence of a specified event. Most event-linked bonds issued to date have been linked to catastrophes such as hurricanes and earthquakes, although bonds also have been issued that respond to mortality events, personal automobile insurance, and claims made in casualty insurance (Swiss Re, 2006).

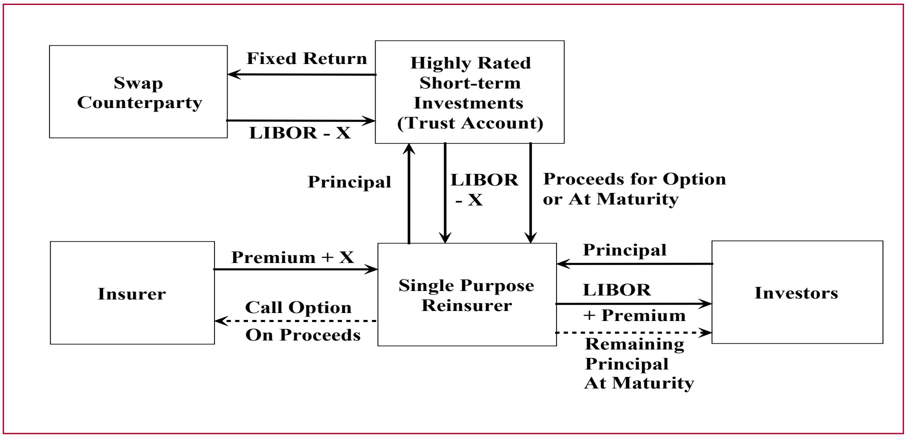
The first successful CAT bond was an US$85 million issue by Hannover Re in 1994 (Swiss Re, 2001). The first CAT bond issued by a nonfinancial firm, occurring in 1999, covered earthquake losses in the Tokyo region for Oriental Land Company, the owner of Tokyo Disneyland. Although various design features were tested in the early stages of the CAT bond market, more recently CAT bonds have become more standardised. The standardisation has been driven by the need for bonds to respond to the requirements of the principal stakeholders, including sponsors, investors, rating agencies, and regulators.

CAT bonds often are issued to cover the so-called *high layers* of reinsurance protection; for example, protection against events that have a probability of occurrence of 0.02 or less (that is, a *return period* of at least 50 years). The higher layers of protection often go unreinsured by ceding companies for two primary reasons: 1) for events of this magnitude, ceding insurers are more concerned about the credit risk of the reinsurer, and 2) high layers tend to have the highest reinsurance margins or pricing spreads above the expected loss (Cummins, 2007). Because CAT bonds are fully collateralised, they eliminate concerns about credit risk, and because catastrophic events have low correlations with investment returns, CAT bonds may provide lower spreads than high-layer reinsurance because they are attractive to investors for diversification. CAT bonds are more transparent than many other types of asset-backed securities (ABS) such as the mortgage-backed securities that played a major role in the financial crisis that began in 2007. Because the payoff on the bonds comes from the assets in the trust, the bond sponsor retains a strong interest in the quality of the assets backing the bond. Therefore, there is less moral hazard than with other types of ABS. As a result of these features, CAT bonds weathered the financial crisis much more successfully than other types of ABS.

CAT bonds also can lock in multiyear protection (unlike traditional reinsurance, which usually is for a one-year period) and shelter the sponsor from cyclical price fluctuations in the reinsurance market. The multiyear terms (or *tenors*) of most CAT bonds also allow sponsors to spread the fixed costs of issuing the bonds over a multiyear period, reducing costs on an annualised basis.

A typical CAT bond structure is diagrammed in Figure 1. The transaction begins with the formation of a single purpose reinsurer (SPR). The SPR issues bonds to investors and invests the proceeds in safe, short-term securities such as government bonds or AAA corporates, which are held in a trust account. Embedded in the bonds is a call option that is triggered by a defined catastrophic event. On the occurrence of the event, proceeds are released from the SPR to help the insurer pay claims arising from the event. In most CAT bonds, the principal is fully at risk; that is, if the contingent event is sufficiently large, the investors could lose the entire principal in the SPR. In return for the option, the insurer pays a premium to the investors. The fixed returns on the securities held in the trust are usually swapped for floating returns based on LIBOR (London interbank offered rate) or some other widely accepted index. The reason for the swap is to immunise the insurer and the investors from interest-rate risk. Consequently, the investors receive LIBOR plus the risk premium in return for providing capital to the trust. If no contingent event occurs during the term of the bonds, the principal is returned to the investors upon the expiration of the bonds.

Figure 1: CAT bond with single purpose reinsurer



Source: Cummins and Barrieu (2012).

Some CAT bond issues have included *principal protected tranches*, where the return of principal is guaranteed. In this tranche, the triggering event would affect the interest and spread payments and the timing of the repayment of the principal. For example, a two-year CAT bond subject to the payment of interest and a spread premium might convert into a 10-year zero-coupon bond that would return only the principal. Principal-protected tranches have become relatively rare, primarily because they do not provide as much risk capital to the sponsor as a principal-at-risk bond.

Insurers prefer to use an SPR to capture the tax and accounting benefits associated with traditional reinsurance.[7] Investors prefer SPRs to isolate the risk of their investment from the general business and insolvency risks of the insurer, thus creating an investment that is a "pure play" in catastrophic risk. In addition, the bonds are fully collateralised, with the collateral held in trust, insulating the investors from credit risk. As a result, the issuer of the securitisation can realise lower financing costs through segregation. The transaction also is

7 Harrington and Niehaus (2003) argue that one important advantage of CAT bonds as a financing mechanism is that corporate tax costs are lower than for financing through equity and that the bonds pose less risk in regard to potential future degradations of insurer financial ratings and capital structure than financing through subordinated debt.

more transparent than a debt issued by the insurer, because the funds are held in trust and are released according to carefully defined criteria.

The bonds are attractive to investors, because catastrophic events have low correlations with returns from securities markets and hence are valuable for diversification purposes (Litzenberger, Beaglehole, and Reynolds, 1996). Although the US$100 billion-plus "Big One" hurricane or earthquake could drive down securities prices, creating systematic risk for CAT securities, systematic risk is considerably lower than for most other types of assets, especially during more normal periods.

In the absence of a traded underlying asset, CAT bonds and other insurance-linked securities have been structured to pay off on three types of triggering variables: 1) *indemnity triggers*, where payouts are based on the size of the sponsoring insurer's actual losses; 2) *index triggers*, where payouts are based on an index not directly tied to the sponsoring firm's losses; 3) *parametric triggers,* based on the physical characteristics of the event; 4) *modelled loss triggers*, based on the results of a simulation model; or, 5) *hybrid triggers*, which blend more than one trigger in a single bond.

With industry loss indexes, the payoff on the bond is triggered when estimated industry wide losses from an event exceed a specified threshold. For example, the payoff could be based on estimated catastrophe losses in a specified geographical area provided by Property Claims Services (PCS), the same organisation that provided the indexes for the CBOT options. Other indices that have been used include the Swiss Re Sigma index, started in 1970, which provides catastrophe indices by country and state, the worldwide NatCatService provided by Munich Re, the RMS Paradex index for the U.S. and Europe, and the PERILS Industry Loss Index for Europe. Several criteria enter into the choice of an index. An index should have the following characteristics: (1) transparency, i.e., observable, quantifiable, and clearly defined; (2) simplicity, i.e., sufficiently simple such that users can gauge the risk/benefit of the contract; (3) released promptly following covered events; (4) accurate and reliable, i.e., subject to minimal revision; (5) consistently available over time to help users analyse correlations between the index and past events, and (6) be published by an independent and credible provider to reduce moral hazard and increase reliability.[8]

With a parametric trigger, the bond payoff is triggered by specified physical measures of the catastrophic event, such as the wind speed and location of a hurricane or the magnitude and location of an earthquake. This can be in the form of a *pure parametric* trigger based simply on specified physical measurements or a *parametric index* trigger, which uses more complicated formulas and more detailed physical measurements of the event.

A modelled-loss index is calculated using a model provided by one of the major catastrophe modelling firms—Applied Insurance Research (AIR) Worldwide, EQECAT, or Risk Management Solutions (RMS). The index could be generated by running the model on industry-wide exposures for a specified geographical area. Alternatively, the model could be run on a representative sample of the sponsoring insurer's own exposures. In each case, an actual event's physical parameters are used in running the simulations.

A number of factors may be considered in the choice of a trigger when designing a CAT bond (Guy Carpenter, 2005; Mocklow, DeCaro and McKenna, 2002). The choice of a trigger involves a trade-off between moral hazard (transparency to investors) and basis

8 For further discussion, see Swiss Re (2009).

risk. Indemnity triggers are often favoured by insurers and reinsurers, because they minimise basis risk, that is, the risk that the loss payout of the bond will be greater or less than the sponsoring firm's actual losses. However, indemnity triggers require investors to obtain information on the risk exposure of the sponsor's underwriting portfolio, which can be difficult, especially for complex commercial risks. In addition, indemnity triggers have the disadvantage to the sponsor that they require disclosure of confidential information on the sponsor's policy portfolio. Contracts based on indemnity triggers may require more time than non-indemnity triggers to reach final settlement due to the length of the loss adjustment process.

Investors tend to favour index triggers, because they minimise the problem of moral hazard; that is, they maximise the transparency of the transaction. Moral hazard can occur if the issuing insurer fails to settle catastrophe losses carefully and appropriately (that is, overpays) because of the correlation of the bond payout with its realised losses. The insurer might also excessively expand its premium writings in geographical areas covered by the bond. Although CAT bonds almost always contain copayment provisions to control moral hazard, moral hazard remains a residual concern for some investors. Indexes also have the advantage of being measurable more quickly after the event than indemnity triggers, which allows the sponsor to receive payment under the bond more quickly.

The principal disadvantage of index triggers is that they expose the sponsor to a higher degree of basis risk than do indemnity triggers. The degree of basis risk varies depending upon several factors. Parametric triggers tend to have the lowest exposure to moral hazard but may have the highest exposure to basis risk. However, even with a parametric trigger, basis risk often can be reduced substantially by appropriately defining the location where the event severity is measured and using more detailed measurements. Likewise, industry-loss indexes based on narrowly defined geographical areas tend to have less basis risk than do those based on wider areas (Cummins, Lalonde, and Phillips, 2004).

Modelled-loss indexes may become the favoured mechanism for obtaining the benefits of an index trigger without incurring significant basis risk. However, modelled-loss indexes are subject to "model risk," that is, the risk that the model will overestimate or underestimate the losses from an event. This risk is diminishing over time as the modelling firms continue to refine their models.

2.4. Sidecars

An innovative financing vehicle with some similarities to both conventional reinsurance and CAT bonds is the *sidecar*. Sidecars date back to at least 2002 but became much more prominent following the 2005 hurricane season (A.M. Best Company, 2006). Sidecars are special-purpose vehicles formed by insurance and reinsurance companies to provide additional capacity to write reinsurance, usually for property catastrophes and marine risks, and typically serve to accept retrocessions exclusively from a single reinsurer. Sidecars are typically off-balance-sheet, formed to write specific types of reinsurance, such as property-catastrophe quota share or excess of loss, and generally have limited lifespans. Reinsurers receive override commissions for premiums ceded to sidecars. Most sidecars are capitalised by private investors such as hedge funds. Sidecars receive premiums for the reinsurance underwritten and are liable to pay claims under the terms of the reinsurance contracts. In addition to providing capacity, sidecars also enable the sponsoring reinsurer to move some of its risks off-balance-sheet, thus improving leverage.

Sidecars can also be formed quickly and with minimal documentation and administrative costs. For further discussion, see Cummins (2007) and Lane (2007).

2.5. Catastrophic Equity Puts (Cat-E-Puts)

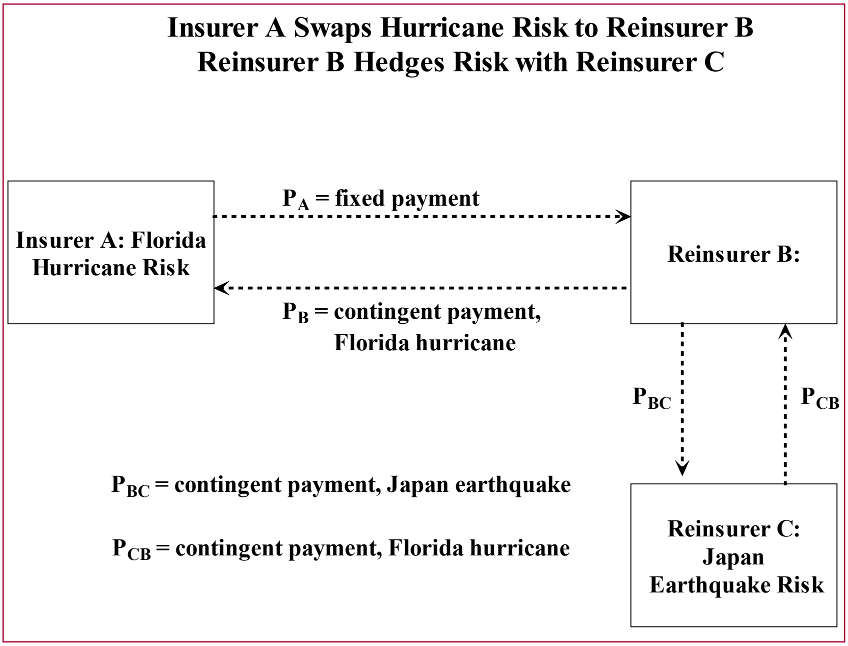
Another capital market solution to the catastrophic loss financing problem is catastrophic equity puts (Cat-E-Puts). Unlike CAT bonds, Cat-E-Puts are not asset-backed securities, but options. In return for a premium paid to the writer of the option, the insurer obtains the option to issue preferred stock at a pre-agreed price on the occurrence of a contingent event. This enables the insurer to raise equity capital at a favorable price after a catastrophe, when its stock price is likely to be depressed. Cat-E-Puts tend to have lower transactions costs than CAT bonds have, because there is no need to set up an SPR. However, because they are not collateralised, these securities expose the insurer to counterparty performance risk. In addition, issuing the preferred stock can dilute the value of the firm's existing shares. Thus, although Cat-E-Puts have been issued, they have not become nearly as important as CAT bonds.

2.6. Catastrophe Risk Swaps

Like Cat-E-Puts, catastrophe risk swaps generally are not prefunded but relay only an agreement between two counterparties. Catastrophe swaps can be executed between two firms with exposure to different types of catastrophic risk. An example of a catastrophic risk swap is provided in Figure 2. In the example, a reinsurer with exposure to California earthquake risk agrees to swap its risk with another reinsurer with exposure to Japanese earthquake risk. Another example is the swap executed by Mitsui Sumitomo Insurance and Swiss Re in 2003, which swapped US$12 billion of Japanese typhoon risk against US$50 million each of North Atlantic hurricane and European windstorm risk. Swaps are facilitated by the Catastrophic Risk Exchange (CATEX), a web-based exchange where insurers and reinsurers can arrange reinsurance contracts and swap transactions. In 2007 the newly formed Caribbean Catastrophe Reinsurance Facility (CCRF), which is jointly sponsored by 16 Caribbean countries to provide immediate liquidity to their governments in the event of a hurricane or earthquake, arranged a US$30 million swap to transfer part of their risk to capital markets (Cummins and Mahul, 2008).

The event or events that trigger payment under the swap are carefully defined in the swap agreement. For example, a parametric trigger could be used, such as an earthquake of a specified magnitude in Tokyo for the Japanese side of the swap and a comparable earthquake in San Francisco for the U.S. side. The swap can be designed to ensure that the two sides of the risk achieve *parity*—that the expected losses under the two sides of the swap are equivalent. This obviously requires an extensive modelling exercise, using models developed internally or by catastrophe modelling firms. With parity, there is no exchange of money at the inception of the contract, only on the occurrence of one of the triggering events. The swap also defines a specified amount of money (such as US$200 million) to be paid if an event occurs. Some contracts have sliding-scale payoff functions, which specify full payout for the severest events and partial payout for smaller events. Swaps can be annual or can span several years. Swaps also can be executed to fund multiple risks simultaneously, such as swapping North Atlantic hurricane risk for Japanese typhoon risk in the same contract as the earthquake swap.

Figure 2: Catastrophe (Risk) Swap



Source: Cummins and Barrieu (2012).

Swaps may be attractive substitutes for reinsurance, CAT bonds, and other risk-financing devices. Swaps enable the reinsurer to simultaneously lay off some of its core risk and obtain a new source of diversification by exchanging uncorrelated risks with the counterparty (Takeda, 2002). Thus, swaps may enable reinsurers to operate with less equity capital. Swaps also are characterised by low transaction costs and reduce current expenses, because no money changes hands until the occurrence of a triggering event. The potential disadvantages of swaps are that modelling the risks to achieve parity can be challenging and not necessarily completely accurate. Swaps also may create more exposure to basis risk than some other types of contracts and also create exposure to counterparty non-performance risk. The possibility of non-performance risk provides another potential role for an investment bank or reinsurer to execute hedges to enhance the credit quality of the swap. However, such hedging would add to the transactions costs.

2.7. Industry Loss Warranties

As explained further below, a possible impediment to the growth of the CAT securitisation market has to do with whether the securities are treated as reinsurance by regulators, and hence given favourable regulatory accounting treatment. It seems clear that properly structured *indemnity* CAT securities (those that pay off based on the losses of the issuing insurer) will be treated as reinsurance. However, U.S. regulators are still deliberating about the regulatory treatment of index-linked risk-financing securities. Nevertheless, regulation does not seem to have impeded the strong growth of the CAT bond market during the past several years, because sponsors and their bankers have found various ways to finesse potential regulatory problems. For example, even if the SPV is an offshore vehicle, the trust holding the assets can be onshore, mitigating regulatory concerns regarding credit risk of offshore entities.

Dual-trigger contracts known as *industry loss warranties* (ILWs) also overcome regulatory objections to non-indemnity bonds (McDonnell, 2002). ILWs are dual-trigger reinsurance contracts that have a *retention trigger* based on the incurred losses of the insurer buying the contract, and also a *warranty trigger* based on an industry-wide loss index. That is, the contracts pay off on the dual event that a specified industry-wide loss index exceeds a particular threshold at the same time that the issuing insurer's losses from the event equal or exceed a specified amount. Both triggers have to be hit for the buyer of the contract to receive a payoff. The issuing insurer thus is covered in states of the world when its own losses are high and the reinsurance market is likely to enter a hard-market phase. ILWs cover events from specified catastrophe perils in a defined geographical region. For example, an ILW might cover losses from hurricanes in the south-eastern United States. The term of the contract is typically one year. ILWs may have *binary triggers*, where the full amount of the contract pays off once the two triggers are satisfied, or *pro rata triggers*, where the payoff depends upon how much the loss exceeds the warranty.

The principal advantages of ILWs are that they are treated as reinsurance for regulatory purposes, and that they can be used to plug gaps in reinsurance programs. They also represent an efficient use of funds in that they pay off in states of the world where both the insurer's losses and industry-wide losses are high. The principal disadvantage is that ILWs are supplied primarily by reinsurers and hence do not access the capacity of the broader capital markets. However, ILWs can be packaged and securitised to broaden the capital base.

3. The Risk-Linked Securities Market

This section reviews the recent history and current status of the risk-linked securities market. The focus is primarily on CAT bonds, the most commonly used securitised structure in financing catastrophic risk.

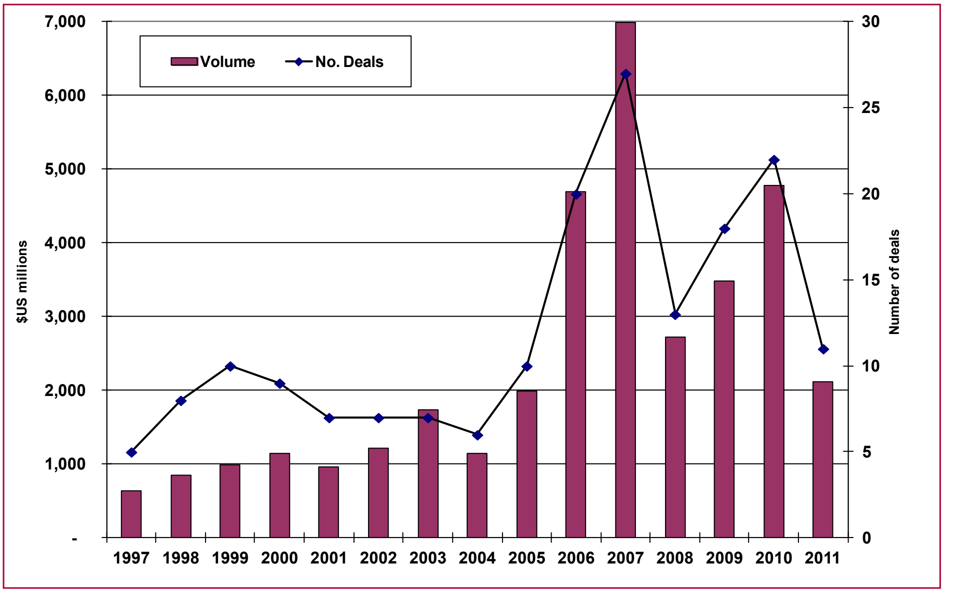
3.1. The CAT bond market: size and bond characteristics

Although the CAT bond market seemed to get off to a slow start in the late 1990s, the market has matured and now has become a steady source of capacity for both primary insurers and reinsurers. The market is growing steadily and set new records for market issuance volume in 2005, 2006, and 2007. The market fell off due to the financial crisis in 2008. However, it rebounded in 2009, and 2010 was the second largest year in history in terms of issue volume.

CAT bonds make sound economic sense as a mechanism for funding mega-catastrophes. Catastrophes such as Hurricane Katrina and the fabled and yet to be realised US$100 billion-plus "Big One" in California, Tokyo, or Florida are large relative to the resources of the insurance and reinsurance industries but are small relative to the size of capital markets. A US$100 billion loss would represent less than 0.5 per cent of the value of U.S. securities markets and could easily be absorbed through securitised transactions. Securities markets also are more efficient than insurance markets in reducing information asymmetries and facilitating price discovery. Thus, it makes sense to predict that the CAT bond market will continue to grow, and that CAT bonds will eventually be issued in the public securities markets, rather than being confined primarily to private placements as at present.

The new-issue volume in the CAT bond market from 1997 through September 2011 is shown in Figure 3. The data in the figure apply only to non-life CAT bonds. Recently, event-linked bonds have also been issued to cover third-party commercial liability, automobile quota share, and indemnity-based trade credit reinsurance. There is also a growing market in life insurance securitisations of various types.

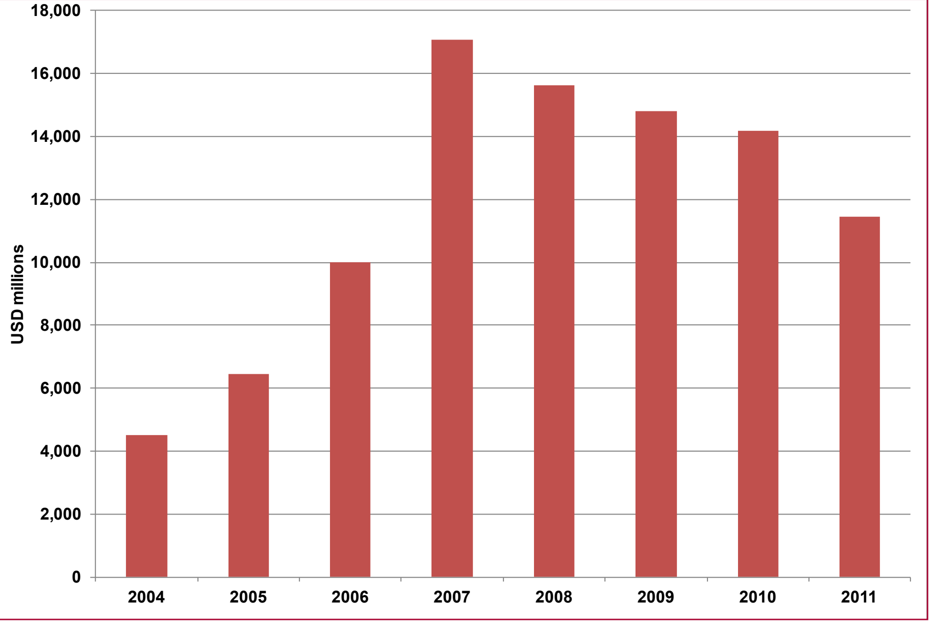
Figure 3: Non-life CAT bonds: new issues



Source: GC Securities (2008), A.M. Best (2010, 2011), Swiss Re (2009, 2010, 2011), 2011 data through 30 September.

Figure 3 shows that the market has grown from less than US$1 billion per year in 1997 to more than US$7 billion per year in 2007. Volume dropped to US$2.7 billion in 2008 due to the financial crisis but rose again to US$4.8 billion in 2010. The number of transactions also increased, reaching 27 in 2007. There were 13 deals in 2008 but the number increased to 22 in 2010. A substantial number of the issuers in 2005–2011 were first-time sponsors of CAT bonds, although established players such as Swiss Re continue to play a major role. Figure 4 shows the amount of risk capital outstanding in the CAT bond market. Risk capital outstanding represents the face value of all bonds still in effect in each year shown in the figure. US$17 billion of risk capital was outstanding by the end of 2007. Since that time, the amount of risk capital has declined, as new issues have not kept up with maturities. The amount of outstanding risk capital stood at US$11.5 billion as of 30 June 2011.

Figure 4: CAT bonds: risk capital outstanding

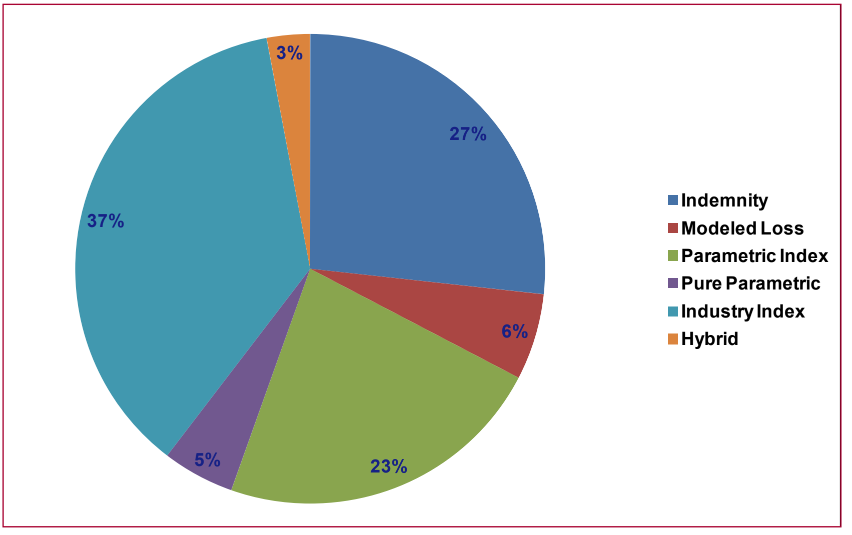


Source: Swiss Re (2011). Volume statistics are for year-end except for 2011, which is as of 30 June.

The characteristics of CAT bonds continue to evolve, but the overall trend is toward a higher degree of standardisation. The distribution of triggers of outstanding CAT bonds by volume as of 30 June 2011 is shown in Figure 5. The leading type of index is the industry index trigger, accounting for 37 per cent of outstanding bonds by volume. The second leading trigger is the indemnity trigger, accounting for 27 per cent of outstanding bonds. Parametric index and pure parametric triggers account for 28 per cent of bonds, while modelled loss triggers are used for 6 per cent and hybrid triggers by 3 per cent of outstanding bonds.

The trends in bond tenor are shown in Figure 6, which shows bond tenor by new issue volume for years 2005-2011. In this chart, years are defined as ending in quarter 1, e.g., the data for 2005 are based on bonds issued from the second quarter of 2004 through the first quarter of 2005 (Lane and Beckwith, 2011). Even though there were some bonds issued during 2005 and 2006 with maturities longer than 60 months, the market seems to have converged on shorter-term issues, with three year bonds constituting the majority of issues during the period shown in the figure. Maturities greater than one year tend to be favoured, because they provide a steady source of risk capital that is insulated from year-to-year swings in reinsurance prices, and because they permit issuers to amortise costs of issuance over a longer period, reducing per period transactions costs. Bonds longer than five years are not favoured by the market, because market participants would like to reprice the risk periodically to reflect new information on the frequency and severity of catastrophes and to recognise changes in the underwriting risk profile of the sponsor.

Figure 5: Triggers of outstanding CAT bonds (as of 30 June 2011)



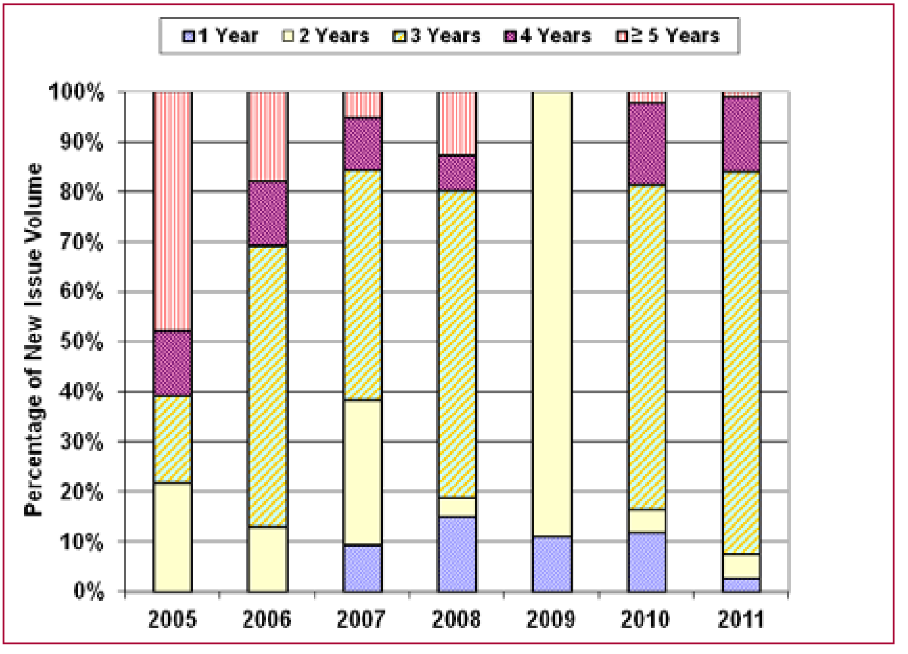
Source: Swiss Re (2011).

Figure 7 shows the regions and perils covered by CAT bonds outstanding as of 30 June 2011. The U.S. predominates as the primary source of demand for CAT bonds. U.S. windstorm coverage accounts for 25 per cent of outstanding bonds, U.S tornado for 5 per cent, and U.S. winter storm for another 4 per cent. U.S. earthquake coverage accounts for another 45 per cent of outstanding bonds, including California, the Central U.S., and the Pacific Northwest. Therefore, in total, the U.S. accounts for 79 per cent of all outstanding CAT bond coverage. Smaller proportions of outstanding bonds cover "off-peak" perils and regions, including European windstorm (7 per cent), Japan earthquake (4 per cent), and Japan typhoon (3 per cent). Bonds on other regions/perils such as Mexican earthquake and hurricane account for only 7 per cent of outstanding bonds. As expected, spreads are higher on the "off peak" perils and regions than for the U.S. because off-peak bonds are very valuable to investors for diversification of their catastrophe risk (Cardenas, *et al.*, 2007).

The vast majority of CAT bonds are sponsored by insurers or reinsurers. However, there have also been a limited number of corporate and government issuers. There were only six corporate issues during the period 1997-2007, compared to 110 issues by insurers and reinsurers (GC Securities, 2008), and there have been few non-insurance issues since 2007. The corporate issues included bonds sponsored by Oriental Land Company (the operator of Tokyo Disneyland) in 1999 and East Japan Railway in 2007. A 2011 transaction provides €150 million of European windstorm coverage for mainland France to benefit a subsidiary of Electricité de France.[9]

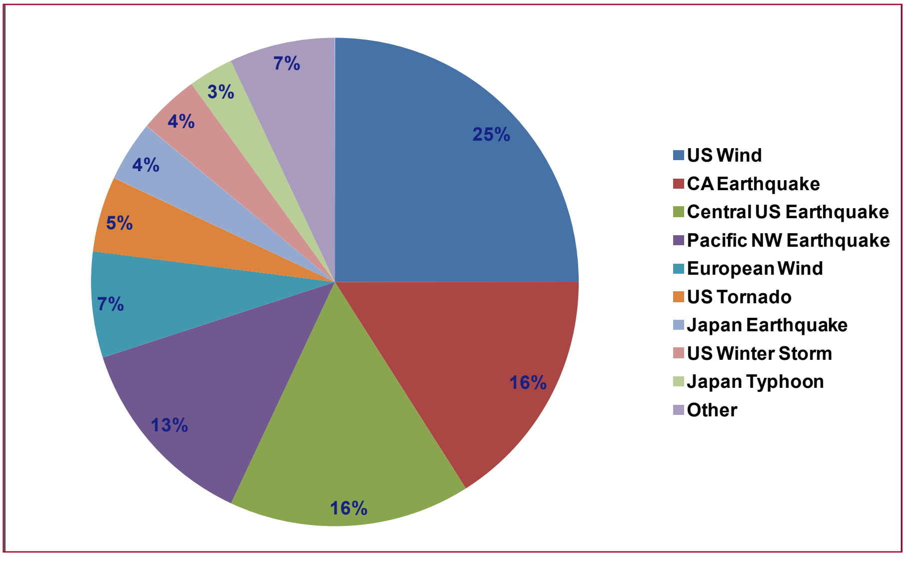
9 A description of CAT bond deals is provided at the *http://www.artemis.bm/deal_directory/.*

Figure 6: CAT bond transactions by term to maturity



Source: Lane and Beckwith (2011). Data for year x are from quarter 2 of year x-1 to quarter 1 of year x.

Figure 7: Perils covered by outstanding CAT bonds (as of 30 June 2011)



Source: Swiss Re (2011).

In 2006, the first government-issued disaster-relief bond placement was executed to provide funds to the Government of Mexico to defray costs of disaster recovery. The bond transferred US$160 million of Mexican earthquake risk to the capital markets through a special-purpose vehicle (CAT-Mex Ltd.). The deal was part of an overall US$450 million transaction, involving both conventional reinsurance and securitisation. The transaction was executed by Swiss Re and Deutsche Bank Securities. Because Mexican earthquake risk has very low or zero correlation with the risks covered by other newly issued and outstanding CAT bonds, the Mexican bond is very valuable to CAT bond investors for diversification purposes. Accordingly, the premium on the Mexican bonds was quite low, about 2.3 percent over LIBOR for the Class A bonds issued by CAT-Mex. This compares very favourably with the premiums on prior earthquake bonds issued on the United States and Japan (Cardenas, 2006). Mexico followed up this issue with Multicat Mexico 2009, valued at US$290 million, protecting against earthquakes and both Pacific and Atlantic hurricane events.

In the past, the CAT bond market has been criticised for lack of investor interest. However, that critique of the market is now outdated—recent data suggest broad market interest in CAT bonds among institutional investors. Figure 8 shows the percentage of new issue volume by investor type from 1 January 2008 through 30 June 2011. During this period, insurers and reinsurers accounted for only 13 per cent of demand, suggesting that substantial external capital has been attracted to the market. Dedicated CAT funds accounted for 64 per cent of the market during this period, and money managers and hedge funds accounted for 21 per cent. The increasingly broad market interest in the bonds suggests that the bonds are attractive to investors and are playing an increasingly important role relative to conventional reinsurance.

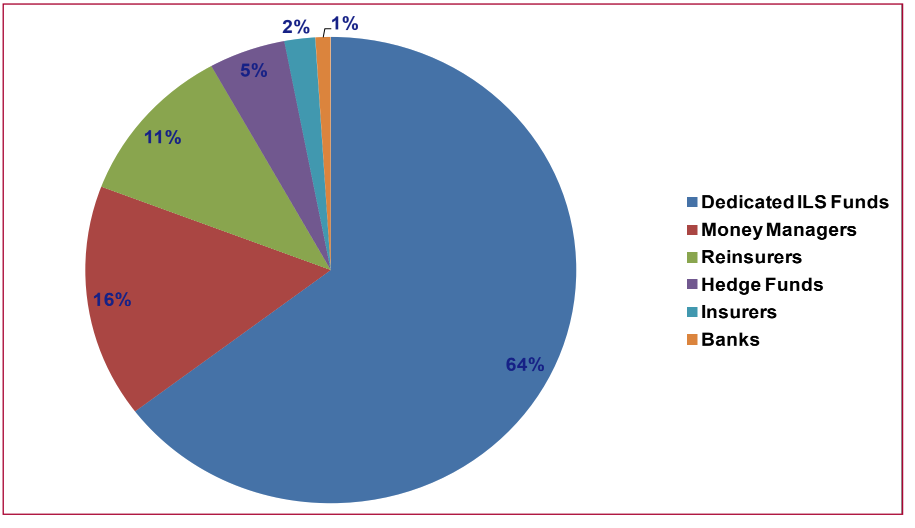
In addition to CAT bonds, a significant amount of new capital has been raised through sidecars, especially following the 2005 hurricane season. Eleven sidecar transactions took place in 2006, totalling US$2.9 billion in risk capital. In 2005, there were eight transactions, which raised a total of US$2.5 billion. There was some indication that sidecars were competing with CAT bonds for risk capital of interested investors in 2005, leading to rising prices and tightening capacity in the CAT bond market (Guy Carpenter, 2006). Although sidecar activity has been relatively limited during the past few quarters, sidecar capacity will be forthcoming as needed (A.M. Best Company, 2011).

Obtaining a financial rating is a critical step in issuing a CAT bond, because buyers use ratings to compare yields on CAT bonds with other corporate securities. Consequently, almost all bonds are issued with financial ratings. Some CAT bonds have been issued with ratings below investment grade (BBB) but the most common ratings are BB and B (Lane and Beckwith, 2011). Although low bond ratings are generally bad news for bond issuers, they are not necessarily adverse in the CAT bond market. Because CAT bonds are fully collateralised, CAT bond ratings tend to be determined by the probability that the bond principal will be hit by a triggering event rather than the credit rating of the issuer. Thus, the bond ratings merely indicate the layer of catastrophic risk coverage provided by the bonds.

The first publicly acknowledged total loss of principal for a CAT bond took place in 2005, although there apparently have been earlier wipe-outs that were not publicly announced (Lane and Beckwith, 2006). Kamp Re, a US$190 million bond issued in July 2005 under the sponsorship of Zurich Financial, apparently paid out its entire principal to the sponsor as a result of Hurricane Katrina claims (Guy Carpenter, 2006). Kamp Re had an indemnity trigger, and the short-term impact of the wipe-out was to increase investor wariness of indemnity-based transactions. Indemnity transactions rebounded in later periods, however, due to a surge of primary insurer CAT bond issues (Swiss Re, 2007).

The longer-term impact of the Kamp Re wipe-out on the CAT bond market was generally favourable. The smooth settlement of Kamp Re established an important precedent in the market, showing that CAT bonds function as designed, with minimal confusion and controversy between the sponsor and investors. Thus, the wipe-out served to "reduce the overall uncertainty associated with this marketplace and therefore increase both investor and sponsor demand for these instruments" (Guy Carpenter, 2006, p. 4).

Figure 8: CAT bonds: volume purchased by investor type, 1 January 2008-30 June 2011



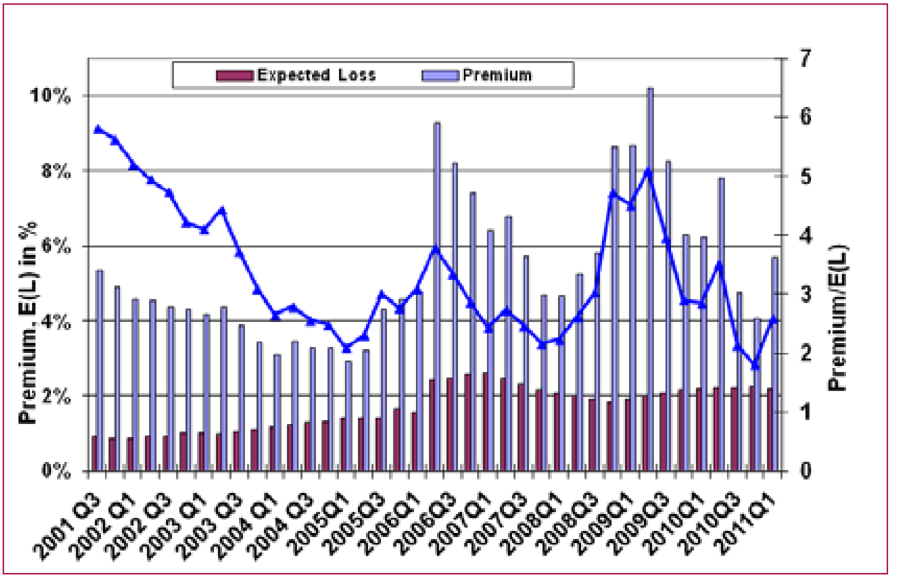
Source: Swiss Re (2011).

3.2. CAT bond prices

CAT bonds are priced at spreads over LIBOR, meaning that investors receive floating interest plus a spread or premium over the floating rate. In the early years of the CAT bond market, CAT bonds were somewhat notorious for having high spreads, and much has been written trying to explain the magnitude of the spreads (for example, Froot, 2001). However, in more recent years, the spreads have become comparable to the cost of reinsurance for similar layers of coverage, showing CAT bonds to be competitive with conventional reinsurance.

The secondary market yields on CAT bonds are shown quarterly from the third quarter of 2001 through the first quarter of 2011 in Figure 9. The figure shows the average expected loss, the average premium on the bonds (spreads over LIBOR), and the ratio of the premium to the expected loss. The data are from Lane Financial LLC.

Figure 9: CAT bond premiums and expected loss

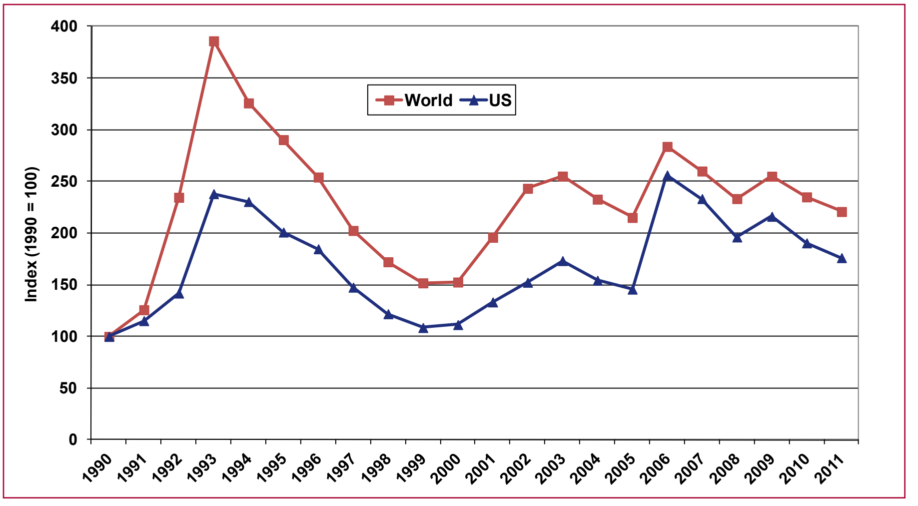


Source: Lane Financial. Premiums and expected losses are percentages of bond principal.

Prior to Hurricane Katrina, there was a somewhat steady decline in yields and a slight increase in the expected loss, implying a general decline in the cost of financing through CAT bonds. The ratio of the premium to expected loss was about 6.0 in early 2001, and prior research covering periods before 2001 showed median ratios of yields to expected loss of about 6.5 for CAT bonds (Cummins, Lalonde, and Phillips, 2004). However, the ratio of premium to expected loss began a somewhat steady decline in 2001 and stood at 2.1 in the first quarter of 2005. Not surprisingly, yields and spreads increased following Katrina as the market tightened and investors had opportunities to place capital in other catastrophic risk vehicles, such as sidecars. The spread ratio peaked at 3.7 in the second quarter of 2006 but declined again to 2.1 by the fourth quarter of 2007. The spread ratio increased sharply with the advent of the financial crisis, peaking at 5.1 in the second quarter of 2009. Thereafter, the ratio generally declined and stood at 2.6 in the first quarter of 2011. Thus, the CAT bond market was able to withstand the post-Katrina competition for capital without returning to the high relative spreads of earlier periods. Consequently, it seems that the earlier critique of CAT bonds (that is, excessive spreads) no longer applies. This is the expected result in a market where there is growing investor interest and expertise as well as growing volume, which adds to market liquidity.

Although there is clearly some cyclicality in CAT bond spreads, cycles are also present in the market for catastrophe reinsurance. This is apparent from Figure 10, which shows the Guy Carpenter catastrophe reinsurance rate on line index from 1990-2011. The index spiked dramatically in response to Hurricane Andrew in 1992 and spiked again following the 2001 World Trade Center terrorist attack and the 2005 hurricane season. There was a smaller spike in 2009, perhaps attributable to Hurricane Ike. Therefore, as a risk hedging device, reinsurance is subject to price instability.

Figure 10: Catastrophe reinsurance rate on line indices



Source: Guy Carpenter (2011).

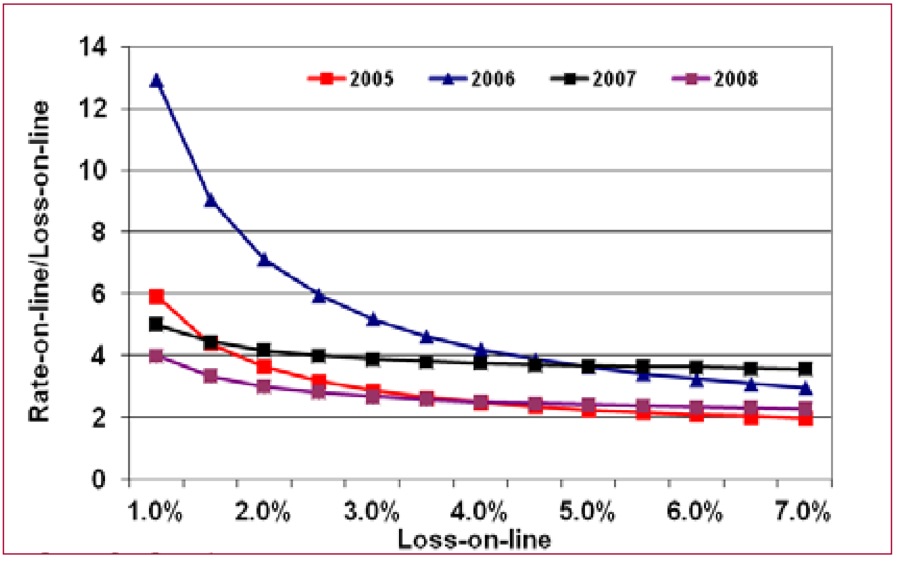
Comparison of CAT bond and catastrophe reinsurance pricing is difficult because of the general lack of systematic data on reinsurance prices. However, based on some unpublished data from Guy Carpenter, it is possible to provide a general indication of the comparative prices of CAT bonds and reinsurance. Guy Carpenter provided data on the relationship between the rate on line and the loss on line for catastrophe reinsurance. The rate on line (ROL) is defined as the reinsurance premium divided by the policy limit, and the loss on line (LOL) is the expected loss on the contract divided by the policy limit.

The ratio of the ROL to the LOL is analogous to the ratio of the yield to expected loss on CAT bonds shown in Figure 11. The Guy Carpenter ROL and LOL data are based on average figures for Guy Carpenter clients buying reinsurance in 2005-2008 and apply to U.S. national primary insurers.

Like the CAT bond yield-to-expected-loss ratios, the ratios of rates on line to expected loss on line for Guy Carpenter clients are significantly higher in 2006 than in the other years shown in the table for the low frequency events, reflecting the effects of Hurricanes Katrina, Rita, and Wilma. The ratios are lower for contracts with higher expected losses on line, reflecting the fact that policies with low expected LOL are covering the more risky upper tails of the loss distribution.

As shown in Figure 9, CAT bonds on average tend to have expected losses of between 1 per cent and 2 per cent of principal, and thus are most comparable to catastrophe reinsurance contracts with relatively low LOLs. As shown in Figure 11, the ROL-to-LOL ratios for LOLs of 1 per cent and 2 per cent were 12.9 and 7.1, respectively, but ranged from 4 to 6 at the 1 per cent level in 2005, 2007, and 2008 and between 3 and 4 at the 2 per cent level in these years. These ratios compare with bond premium-to-expected-loss ratios of about 3.3 in 2006, 2.7 in 2005, 2.5 in 2007, and 3.2 in 2008, based on averages of the four quarterly numbers for these years from Figure 9. Hence, even with the more normal pricing of 2005, 2007, and 2008, CAT bonds clearly are "in the ballpark" with regard to reinsurance pricing for national companies and also seem attractive relative to reinsurance even in 2006. Hence, CAT bonds do not appear to be expensive relative to catastrophe reinsurance. Moreover, investment banks have succeeded in reducing transaction costs and speeding the time to market as they have gained experience with insurance-linked securitisations, also making the bonds more attractive to insurers and reinsurers.

Figure 11: Catastrophic reinsurance ratios of rate on line to loss on line



Source: Guy Carpenter.

Another relevant comparison is that of CAT bond yields relative to yields on comparably rated corporate bonds. This comparison has been performed in MMC Securities (2007). The results show that BB CAT bond yields were comparable to yields on BB corporate bond yields from 2001 up until the time of Hurricane Katrina in 2005. Yields on CAT bonds exceeded yields on BB corporates during most of the period from September 2005 through February 2007, although the gap had narrowed considerably by the end of the period. At the peak, yields on CAT bonds were 2–3 per cent higher than the yields on BB corporates. Nevertheless, considering the magnitude of reinsurance prices in 2006 and the uncertainty created by Katrina and other recent catastrophes, the CAT bond market seems to have weathered the storms in very good shape. As mentioned, CAT bonds also performed relatively well during the financial crisis in comparison with other types of asset-backed securities.

4. Conclusion

The CAT bond market is thriving and seems to have reached “critical mass.” The market achieved record bond issuance in 2007, and 2010 had the second highest issuance amount on record. Bond premiums have declined significantly since 2001, and the bonds now seem to be priced competitively with catastrophe reinsurance. Even following Hurricane Katrina, bond premiums were roughly comparable to yields on similarly rated corporate bonds. The amount of risk capital raised through CAT bonds has been growing, and the bonds now account for a significant share of the property-catastrophe reinsurance market. The bonds have an especially important role to play for high coverage layers and in the retrocession market. Thus, the future looks bright for the CAT bond market, and CAT bonds, sidecars, and other innovative capital market solutions will play an increasingly important role in providing risk finance for large loss events. Event-linked bonds are also being used increasingly by primary insurers for lower layers of coverage. However, it remains to be seen whether CAT futures and options will play an important role in catastrophe risk management in the years to come. Basis risk and counterparty credit risk are the primary impediments to the success of these contracts.

References

A.M. Best Company (2011) *Global Reinsurance—Market Review,* Oldwick, NJ: A.M. Best Company.

A.M. Best Company (2006) *2006 Annual Global Reinsurance Report: Reinsurers Humbled, But Most Not Broken, by Hurricane Losses*, Oldwick, NJ: A.M. Best Company.

American Academy of Actuaries (1999) *Evaluating the Effectiveness of Index-Based Insurance Derivatives in Hedging Property/Casualty Insurance Transactions*, Report of the Index Securitization Task Force, Washington, DC.

Cardenas, V. (2006) *Sovereign Financial Disaster Risk Management: The Case of Mexico*, PowerPoint presentation, Ministry of Finance and Public Credit, Mexico City, Mexico.

Cardenas, V., Hochrainer, S., Mechler, R., Pflug, G. and Linnerooth-Bayer, J. (2007) "Sovereign Financial Disaster Risk Management: The Case of Mexico," *Environmental Hazards* 7: 40-53.

Carvill and Company (2007) *Carvill Hurricane Index (CHI): An Index to Measure the Destructive Potential of Hurricanes*, London.

Cowley, A. and J.D. Cummins (2005) "Securitization of Life Insurance Assets and Liabilities," *Journal of Risk and Insurance* 72(2): 193–226.

Cummins, J.D. (2007) "Reinsurance for Natural and Man-Made Catastrophes in the United States: Current State of the Market and Regulatory Reforms", *Risk Management and Insurance Review* 10(2): 179–220.

Cummins, J.D. (2006) "Should the Government Provide Insurance for Catastrophes," *Federal Reserve Bank of St. Louis Review* 88(4): 337–379.

Cummins, J.D. (2005) "Convergence in Wholesale Financial Services: Reinsurance and Investment Banking," *The Geneva Papers on Risk and Insurance—Issues and Practice* 30(2): 187–222, available at *http://genevaassociation.org/PDF/Geneva_papers_on_Risk_and_Insurance/GA2005_GP30(2)_Cummins.pdf*

Cummins, J.D. and Barrieu, P. (2012) "Innovations in Insurance Markets: Hybrid and Securitized Risk-Transfer Solutions," in Georges Dionne, ed., *Handbook of Insurance*, 2nd ed., Boston: Kluwer Academic Publishers.

Cummins, J.D. and Doherty, N.A. (2002) "Capitalization of the Property-Liability Insurance Industry: Overview", *Journal of Financial Services Research* 21(1): 5–14.

Cummins, J.D., Lalonde, D. and Phillips, R.D. (2004) "The Basis Risk of Index-Linked Catastrophic Loss Securities," *Journal of Financial Economics* 71(1): 77–111.

Cummins, J. D. and Weiss, M.A. (2009) "Convergence of Insurance and Financial Markets: Hybrid and Securitised Risk-Transfer Solutions," *Journal of Risk and Insurance* 76(3): 493-545.

Cummins, J. D. and Mahul, O. (2008) *Catastrophe Risk Financing in Developing Countries,* Washington, D.C.: The World Bank.

Dieckmann, S. (2008) *By Force of Nature: Explaining the Yield Spread on Catastrophe Bonds*, Working Paper, Wharton School, Philadelphia, PA: University of Pennsylvania.

Froot, K.A. (2001) "The Market for Catastrophe Risk: A Clinical Examination", *Journal of Financial Economics* 60(2-3): 529–571.

Guy Carpenter (2011) *World Catastrophe Reinsurance Market Review,* New York: Guy Carpenter.

Guy Carpenter (2006) *The Catastrophe Bond Market at Year-End 2005: Ripple Effects from Record Storms,* New York: Guy Carpenter.

Guy Carpenter (2005) *The World Catastrophe Reinsurance Market,* New York: Guy Carpenter.

Harrington, S.E. and Niehaus, G. (2003) "Capital, Corporate Income Taxes, and Catastrophe Insurance", *Journal of Financial Intermediation* 12(4): 365–389.

Lane, M. (2007) *Of Sidecars and Such,* Wilmette, IL: Lane Financial.

Lane, M. and Beckwith, R. (2011) *Prague Spring or Louisiana Morning: Annual Review for the Four Quarters, Q2 2010 to Q1 2011,* Wilmette, IL: Lane Financial.

Lane, M. and Beckwith, R. (2006) *How High Is Up: The 2006 Review of the Insurance Securitisation Market*, Wilmette, IL: Lane Financial.

Lane, M. and Beckwith, R. (2005) *The 2005 Review of the Insurance Securitisation Market: GAME ON!,* Wilmette, IL: Lane Financial.

Litzenberger, R.H., Beaglehole, D.R. and Reynolds, C.E. (1996) "Assessing Catastrophe Reinsurance-Linked Securities as a New Asset Class," *Journal of Portfolio Management* 23: 76–86.

McDonnell, E. (2002) "Industry Loss Warranties," in Morton Lane, ed., *Alternative Risk Strategies,* London: Risk Books.

MMC Securities (2007) *The Catastrophe Bond Market at Year-End 2006: Ripples Into Waves,* New York: MMC Securities.

Mocklow, D., DeCaro, J. and McKenna, M. (2002) "Catastrophe Bonds," in Morton Lane (ed), *Alternative Risk Strategies,* London, UK: Risk Books.

Swiss Re (2011) *Insurance-Linked Securities Market Update*, Vol. XVI (July), Zurich Switzerland: Swiss Reinsurance Company, Ltd.

Swiss Re (2010) *Insurance-Linked Securities Market Update*, Vol. XIV (March), Zurich, Switzerland: Swiss Reinsurance Company, Ltd.

Swiss Re (2009) *The Role of Indices in Transferring Insurance Risks to Capital Markets*, Sigma No. 4/2009, Zurich, Switzerland: Swiss Reinsurance Company, Ltd.

Swiss Re (2007) *Insurance Linked Securities Market Update*, August, Zurich, Switzerland: Swiss Reinsurance Company, Ltd.

Swiss Re (2006) *Securitisation:* New Opportunities for Insurers and Investors, *sigma* No. 7/2006 Zurich, Switzerland: Swiss Reinsurance Company, Ltd.

Swiss Re (2001) *Capital Market Innovation in the Insurance Industry*, *sigma*, No. 3/2001, Zurich, Switzerland: Swiss Reinsurance Company, Ltd.

Takeda, Y. (2002) "Risk Swaps," in Morton Lane, ed., *Alternative Risk Strategies*, London: Risk Books.

Part 2
2011 Events and National Studies

5. 11 March Japanese earthquake, tsunami and nuclear emergency: how insurance responded in post-disaster recovery

Masaaki Nagamura*

1. The "unprecedented" features of the earthquake

1.1. Basic facts of the earthquake

On 11 March 2011, at 2:46 pm (JST), the Tohoku Region in north-eastern Japan was hit by a magnitude 9.0 earthquake. The epicentre was approximately 130 km offshore from the Sanriku Coastline, at a depth of 24 km. The earthquake is recorded as the biggest in terms of its magnitude, whose shock was felt in almost all areas of the four main islands of Japan. The number of aftershocks was also the largest in the history of the nation (JMA, 2011a). The incident caused more than 15,800 fatalities and left about 3,300 missing as of February 2012 (National Police Agency, 2011). The majority of human casualties were due to the ensuing tsunamis which inundated approximately 561km^2 (Geospatial Information Authority of Japan, 2011). In terms of property damage, over 1,140,000 structures were impacted (National Police Agency, 2012).

Seismologists have pointed out the unusual nature of the earthquake, even in a nation well-known for its exposure to earthquakes. Japan is situated where four tectonic plates, namely North American Plate, Eurasian Plate, Pacific Plate and Philippine Sea Plate, intersect (JMA, 2011b). Because of the setting, the country records more than 100,000 earthquakes per year on average, including shakes that are not sensed by humans (Seismological Society of Japan, 2011). The movement of tectonic plates is considered to have caused the earthquake. What made the March 11 earthquake so distinctive was the length of slip demonstrated by the Pacific Plate which was reported to be as much as 30 meters, resulting in the magnitude 9.0 (Mw) earthquake (JMA, 2011c). Studies have also revealed the possibility of a combination of fault activities at different depth levels, which was conceivably a major contributor in generating the powerful tsunami (Hirata *et al*., 2011, p. 11). As it became likely that the shake was actually triggered by a multiple set of seismic activities, coupled with the complexity of the mechanism, the case proved to have gone beyond the anticipated worst-case scenario (Hirata *et al.,* 2011, p. 50 et p. 81).

What added to the tragedy were the unfortunate failures at the nuclear power plants in Fukushima Prefecture, which not only forced 88,000 local residents to evacuate (The Wall Street Journal, 2011a), but raised questions about the level of nuclear safety. With

* It should be noted that the views expressed in this article are strictly those of the author's and not of the entity that he belongs to. Due to the author's background, the article largely reflects the observation from the non-life insurance industry.

the combination of earthquake, tsunami and nuclear accident, the event is often cited as a compound catastrophic disaster (Takenaka *et al*., 2011, p. 165). According to the interim report released by the Investigation Committee on the Accident at the Fukushima Nuclear Power Stations (Investigation Committee on the Accidents at Fukushima Nuclear Power Stations of Tokyo Electric Power Company, 2011), the Fukushima Daiichi power plant was exposed to a tsunami whose wave height exceeded 15 meters at the site. Out of the six nuclear reactors, Reactors 1 through 3 were operating at the time, while the rest were undergoing periodic inspection. Although automatic scram, a system to break the plant operation, reportedly functioned, both external and internal power sources were interrupted, disabling the cooling system which served the reactors and spent fuel storage pool. Within the next four days, each of the Reactors 1, 3 and 4 exploded one after the other, possibly caused by a mass of hydrogen produced by damage to the reactor cores. As a result, considerable amounts of radioactive materials were discharged, which called for the Japanese government to issue an evacuation order for people living in a 20 km radius on 12 March which was later extended to 30 km on 15 March.

2. The impact on economic activities

2.1. Estimated economic loss

According to the International Disaster Database (EM-DAT), published by the Centre for Research on the Epidemiology of Disasters (CRED), the earthquake is recognised as one of the most globally significant since 1900 in terms of economic damage, at JPY16.9 trillion (US$210 billion) (CRED, 2012). It should be noted, however, that the figure does not include consequential loss as well as damages arising from the nuclear power plant accident, which is discussed later. Further to the seismic intensity, ensuing tsunamis had a devastating effect on the north-eastern Pacific coastline. Moreover, there were other additional factors to the striking economic loss.

The impact on the manufacturing supply chain is one element which magnified the disruption of economic activities. It revealed the complex web of manufacturing interdependencies on a global scale, as numerous manufacturing facilities in and out of Japan were forced to either slowdown or cease their production. The most symbolic case involved an automotive microcontroller chip manufacturer whose product line disruption affected assembly lines of leading automobile manufacturers. The supplier was known for having differentiated architecture to meet the designing specification of each vehicle model. The assembly process customised for each model made it extremely challenging for the final assemblers to find an alternate supplier. The situation prompted the car manufacturers to dispatch their engineers to expedite the recovery efforts, which helped the plant to resume operation within three months of the shutdown, much earlier than originally feared. It only took another three months to bring the production back to the pre-11 March level (The Wall Street Journal, 2011b).

An industry survey was run by the Ministry of Economy, Trade and Industry (METI) a month after the event, and its results showed that more than 60 per cent of the manufacturing plants affected by the event had recovered by then, and that 90 per cent would be recovering within three months of the disruption, a better-than-anticipated level of recovery by the sector (Ministry of Economy, Trade and Industry, 2011).

Meanwhile, the trouble at the nuclear power plant caused an electric power shortage in the area which the plant served, including greater metropolitan Tokyo, besides raising public fears of radioactive contamination. The Japanese government responded by setting statutory limits for peak power consumption during the summer. Households and businesses with operations in the area in question were asked to reduce peak time electricity usage by 15 per cent, in order to prevent local power stations from overrunning. Corporate entities followed the order by introducing measures such as running assembly lines during weekends and taking a weekday off, or minimising computer usage by encouraging employees to work at home or recommending off-peak lunch breaks. The restriction was not all negatively received, as it urged corporate entities to rethink how to reduce energy consumption and resulted in energy cost-saving for many. On the other hand, the restriction did add labour and cost burdens to manufacturers in order to meet the expected production output. Another side effect which hit the export-oriented Japanese manufacturers and distributors, was the radioactive contamination surveillance requirement imposed on imports from Japan soon after the event.

The economic damage caused by the nuclear accident is hardly quantifiable, however, according to the nuclear clean-up plan which was released by the government in late 2011, the decommissioning process alone may cost JPY1 trillion (US$12.5 billion) or more, over the course of 40 years. Besides plant-specific remedies, local towns needs to undergo decontamination processes to help their evacuees return home, and it will cost at least another JPY1 trillion. Furthermore, the local farming industry was hit by either radioactive contamination or reputational damage to their products. The compensation is being dealt with by the plant operator pursuant to the Act on Compensation for Nuclear Damage.

Despite the remarkable expedition in resuming manufacturing activities, it is evident that 11 March marked a significant dent in the already sluggish Japanese economy. According to the Cabinet Office's report which was released three months after the event, the total estimated loss to tangible assets, not including the elements arising out of the nuclear plant accident, was JPY16.9 trillion (US$210 billion), which represents approximately 3.3 per cent of the Japanese real gross domestic product.

The national mining and manufacturing sector production fell approximately 15 per cent in the month immediately after the event. As discussed earlier, the disruption of the manufacturing activities in the Tohoku Region, along with the limited power supply, resulted in a nationwide production slowdown.

It was also observed that consumer spending was blunted after the event. In anticipation of prolonged economic slowdown, and the need to prepare for another catastrophic event, the general public opted to save more and refrained from spending on leisure activities or luxury goods. Adding to that, the sympathetic mindset for the victims gave rise to the so-called "voluntary restraint" behaviour across the country, which also contributed to the roughly 2 per cent drop in consumer spending from the preceding month. Consumer confidence showed a steeper decline as was evident in the 18 per cent fall from the previous month in the consumer behavioural index. The reduction in demand helped prevent consumer prices from surging which is typically the case after a catastrophic event (Government of Japan, 2011).

The year 2011 saw a number of misfortunes pile onto Japan. Adding to the multifaceted economic effect of 11 March, the flooding in Thailand, which occurred in October, gave another serious blow to the manufacturing and supply chain of the Japanese industry (see Chapter 9). To make the matter worse, the uncertainty surrounding the ongoing European debt crisis and the Yen's continuing appreciation against Euro and U.S. Dollar is discouraging Japanese exports, resulting in the country's posting an annual trade deficit for the first time since 1980 (The Wall Street Journal, 2012). With the launch of the Reconstruction Agency in early February 2012, it is hoped that the country will elevate the recovery process to reconstruction stage, attract new investments and bounce back to trade surplus.

3. The impact on the insurance industry

3.1. Overview of the financial impact on the non-life insurance industry

The insured loss stemming from the earthquake and tsunami is estimated at JPY3 trillion (US$36 billion), possibly making it the world's second most costly insurance loss since 1970, and the largest in the history of Japanese insurance market (Swiss Re, 2011a; Swiss Re 2011b, p. 32). Even with this scale of loss, the bottom line of the Japanese insurance industry saw limited impact, thanks to the Earthquake Insurance mechanism for residential properties.

3.2. Earthquake insurance for residential properties (NLIRO 2011)

Earthquake had long been considered an uninsurable risk. It was the Niigata earthquake of 1964 which prompted the Japanese Diet to recognise the need for an earthquake insurance system with government involvement. Given the potentially overwhelming financial impact, early policy drafters concentrated on crafting a post-disaster financial relief mechanism for households, as opposed to an indemnity type coverage which is typical of a non-life insurance policy. The study led to the launch of the Earthquake Insurance Act with the objective "*to contribute to the stabilisation of the lives of the affected people*."

With the enactment, the Earthquake Insurance scheme for residential properties was established as a public-private partnership to offer coverage for earthquake, tsunami and volcanic eruption risks. Under the scheme, all licensed private sector non-life insurance companies offer the coverage based on pre-determined common rates and conditions, and adhere to the "no loss, no profit" principles by following an industry-wide mandatory practice to reserve earthquake insurance premium as liability reserve, and by paying out claims from the reserve.

The Japanese government functions as the ultimate reinsurer who assumes the larger portion of the liability as the market-wide total loss amount becomes greater. Currently, the total limit of liability for the scheme is set at JPY5.5 trillion (US$69 billion), within which the Government assumes approximately JPY4.3 trillion (US$54 billion). Total loss from the 11 March earthquake is estimated at JPY1.2 trillion (US$15 billion) under the scheme (GIAJ, 2011a).

The nationwide Earthquake Insurance penetration rate is at 23.7 per cent (GIAJ, 2011b, p. 87), which increased considerably since the last devastating earthquake in Hanshin-Awaji, which hit the port city of Kobe back in 1995, when the figure was at a mere 9.0 per cent (GIAJ, 2011c).

As mentioned earlier, as far as Earthquake Insurance coverage is concerned, there was no impact on the profit-loss statement of the Japanese insurance companies, thanks to the liability reserve which offset insured claims.

3.3. Insurance coverage for industrial customers

Unlike the personal lines of business, earthquake insurance coverage for industrial customers is underwritten subject to pure business interest with no governmental support. The concentration of risk makes industrial earthquake risk especially challenging for primary insurers to retain. A Japanese primary insurer's capability of underwriting earthquake risk is highly dependent on either of the following; the availability of reinsurance capacity, the likelihood of setting up an alternative risk-transfer mechanism such as risk swaps or catastrophe bonds. The confidential nature of individual business deals makes it extremely difficult for a third party to estimate how significant the impact on the non-life insurance industry is bottom line. Product lines with potential coverage include property, cargo, hull and aviation, however, none of these has emerged with considerable impact on the local Japanese insurance market.

Aside from the physical damage coverage, globally active corporate entities were likely to have business interruption coverage for direct damage arising out of an earthquake, and some may even have had contingent business interruption coverage to hedge time element losses attributable to a breakdown of its supplier's facility from an earthquake. One assumes losses from those tailor-made coverages were by no means negligible, but no statistics exist to quantify the impact of such transactions.

What emerged over the course of reinsurance treaty renewals, however, is that the 11 March incident has squeezed the procurement of facultative reinsurance capacity even further, which translates to even tighter coverage availability for corporate customers seeking earthquake coverage in Japan.

3.4. Insurance and nuclear risk

The unfortunate accident at the Fukushima Dai-ichi nuclear power plant turned out to be the most controversial issue that followed the earthquake and tsunami. Liability arising from nuclear accident in Japan is defined under the Law on Compensation for Nuclear Damage and the Ordinance for the enforcement of the Compensation Law (The Law on Compensation for Nuclear Damage, 1961). Under the framework, in case of a nuclear damage loss, the operator is held absolutely and exclusively liable. There is also a requirement for a nuclear power plant operator to secure a nuclear damage liability insurance policy which is offered by a pooling scheme composed of private sector insurance companies, and a nuclear damage liability compensation agreement with the government, which functions as a contingent coverage in case the former does not activate. Each of the policies is offered with a statutory JPY120 billion (US$1.5 billion) per facility limit. Only the latter provides coverage for earthquake and tsunami risks, leaving private insurance companies unaffected by the 11 March incident.

The 11 March incident led to the enactment of the Law on Nuclear Damage Liability Facilitation Fund to prepare for the loss exceeding the statutory limit. Under the law, the Nuclear Damage Liability Facilitation Fund was established to enable existing Japanese nuclear plant operators to mutually assist the troubled operator in case the loss amount exceeds JPY120 billion, by way of funding or offering other types of financial aid, while keeping people suffering from nuclear damage informed of the status. It was the policymakers intent to minimise the burden on taxpayers by not invoking government support, however, there are debates on how to protect the property rights of nuclear plant operators (Law on Nuclear Damage Liability Facilitation Fund, 2011).

4. How insurers responded

4.1. Disaster management and relief operation

Alarmed by the unusual nature of the event, Japanese insurance companies responded by taking emergency measures within hours of the initial quake. Humanitarian aid and restoration of lifelines in the affected areas needed to be dealt with first, followed by delivering essential items including water, food and fuel. Determined to prioritise prompt payment of insurance claims and to offer recovery support for local insurance agents, each company sent a considerable number of extra staff to the Tohoku Region to support the local efforts. In order to handle the enormous number of claims, requests were made to all employees nationwide to assist the local claim offices in the on-site appraisal surveys. The number of extra staff sent to the region counted more than 10,000 industry-wide. The activities were carried out in conjunction with the restoration of the local insurance agents, who are the major distribution source of insurance products. It was proved that the agents played a critical role in reaching out to the affected policyholders. Extra toll-free call centres were set up, both on an individual company level and on an industry-wide level, to respond to the claims and queries of the policyholders. The General Insurance Association of Japan (GIAJ) opened a consultation desk to assist policyholders who had lost their record of their insurance companies (GIAJ, 2011d).

4..2.Collaborative efforts undertaken among GIAJ members

In retrospect, a number of industry-wide collaborative efforts in handling Earthquake Insurance undertaken by GIAJ were built upon the lessons learned from the 1995 Hanshin-Awaji Earthquake.

The impact of tsunami and fire that followed the quake was so widespread that it justified the designation of a total loss area by utilising aerial photos. The designation of a total loss area eliminated the need for physical onsite surveys of properties in the area. The industry also adopted a simplified claim assessment standard to help expedite payments, while agreeing to a common definition in adjusting tsunami claims to enable clear and transparent judgment.

Eleven months after the event, the number of settled Earthquake Insurance claims exceeds 855,000, which represents 99 per cent of the reported claims (GIAJ, 2012). Even with the high percentage of settlement, the industry vows to continue with their efforts in reaching out to policyholders who may have suffered from the incident but are yet to recognise valid coverage under their policy (GIAJ, 2011e).

4.3. Social financial benefit brought about by the Earthquake Insurance

According to a report by a financial periodical, regional bank deposits in the affected area have risen quite substantially from JPY14 trillion (US$175 billion) to JPY17 trillion (US$213 billion), which is roughly a 15 per cent surge over the previous year, as at the end of August 2011 (Kinyuu Zaisei Jijou, 2011, p. 6). Payment from Earthquake Insurance must have contributed significantly to this. With the simplified method of payment, it was very likely that Earthquake Insurance money was among the first to reach the disaster stricken area. GIAJ conducted a survey on the economic effect brought about by the Earthquake Insurance, which exhibited that more than 80 per cent of the respondents would understandably use the insurance money to reconstruct damaged structures, purchase furniture or electric appliances. The estimated payment of JPY 1.2 trillion (US$ 15 billion) generated the first wave of economic impact by stimulating production to catch up with the demand to rebuild structures and to repurchase living appliances. The said first wave of economic effect is likely to have created job opportunities which in turn led to boost consumption, thus setting the stage for the second wave of positive ripple effect. With the spiraling effect of the Earthquake Insurance, the accumulated economic contribution is considered to have reached as much as JPY 3 trillion (US$37.5 billion) (GIAJ, 2011f).

5. Lessons learned from the March 11 incident

5.1. Existing earthquake insurance system: what needs to be fortified

While the Earthquake Insurance system has proved itself effective, the fact that no single insurance company ran into trouble even after the largest insurance loss in the history of Japan demonstrates the financial solidity of the system.

How to maintain financial soundness of the system deserves a lot of attention by relevant parties including policymakers and government officials. As discussed earlier, under the current Earthquake Insurance system, the Japanese Government is involved as a reinsurer. Primary insurers cede 100 per cent of the written Earthquake Insurance exposure to Japan Earthquake Reinsurance Co., Ltd. (JER), a specialised reinsurance company invested by the leading Japanese non-life insurance companies, which retains a portion of the risk and retrocedes the remainder to the member companies and the Government. The total payment limit from a single event is set at JPY5.5 trillion, an amount considered sufficient to withstand a catastrophic event that hits the metropolitan Tokyo area. Burden sharing between the government and the private sector are defined under the relevant ordinances of the Earthquake Insurance Law. The Government liability reserves are managed under the Special Account for Earthquake Reinsurance, separately from the national general accounting (Japan Earthquake Reinsurance, 2011).

As part of the government's efforts to screen and tighten the national budget, there is an ongoing discussion of a working group formed under the Ministry of Finance on the possibility of eliminating the special account status of the scheme and transferring the custodian role of the account to a non-government third party. However, the majority of the working group members took the view that the special account status would give a greater sense of safety and security to the general public, and favoured the existing structure. The Japanese insurance industry is watching the discussion closely and stays focused on making a good case for sustaining the system.

On the distribution front, continued advertising efforts are needed to attract more adherence to the Earthquake Insurance. As part of the effort, the Earthquake Insurance premium became subject to income tax deduction from fiscal year 2006. The hardest hit Miyagi Prefecture had a penetration ratio of 33.6 per cent, which was considerably higher than the national average of 23.7 per cent (GIAJ, 2011g, p. 87). This was partly due to the local government's proactive disaster prevention planning which specified Earthquake Insurance as an effective tool. Drawing from the experience, the importance of working with local municipal offices cannot be neglected.

The system also revealed a number of shortcomings or room for further improvement in the claim handling procedure, which urges the industry and relevant parties to rectify sooner rather than later.

As already discussed, the existing Earthquake Insurance scheme for residential properties is designed to offer financial relief to help the insured reconstruct their post-disaster living, which means that the policy is not intended to provide full indemnity. Even in case of total physical loss to the insured property, the maximum payment an insured would expect is 50 per cent of the insured property value or JPY50 million whichever the lower for buildings, and the same for the movables except for up to JPY10 million instead of JPY50 million. The fact that full indemnity coverage is not readily available in the insurance market needs to be explained carefully to policyholders at times of commencement or renewal.

Some insurers are offering excess earthquake coverage endorsement to policyholders who purchase tailor-made policies to supplement the existing earthquake insurance. Such transactions are exercised outside the scope of governmental support.

Another technical challenge has to do with the claims payment method which is unique to the Earthquake Insurance scheme. In order to facilitate quick appraisal, payment methods are simplified in three categories, namely total loss, half loss and partial loss, based on which the amount receivable would be calculated as 100 per cent, 50 per cent and 5 per cent respectively of the amount insured under the Earthquake Insurance. With the obvious gap between half and partial loss designation in terms of recoverable amount, the appraisal results were often challenged by insureds who were not content with the partial loss judgment. To smooth the gap, one may consider adding an extra layer between the two categories in question. In theory, this approach requires extra premium reserve for the increased coverage, while accruing additional administrative costs for the appraisal procedure. If the additional cost factors are added to the pricing formula, it may disappoint policyholders. Therefore, due care is needed in making adjustments to the existing scheme.

There are constructive arguments on how to incentivise loss prevention through the Earthquake Insurance scheme. The current scheme already incorporates basic rate matrix of location and structure. Locations are classified in four categories depending on the severity of earthquake risk. In terms of structure, there are only two categories, namely non-wooden or wooden structure, with the latter applied a much higher rate than the former. There are some who point out the need for a more granular rating matrix to align the scheme more towards a risk-based model. This may be realised by incorporating extra risk indicators such as ground surface conditions, level of household maintenance, or disaster preparedness of the local municipal authority, into the rating formula. This is another valid argument which deserves careful consideration. For a policyholder who is well prepared for the next earthquake, it is desirable to have an insurance programme which offers a rewarding premium for the efforts paid. However, the shift may lead to a sharp rate increase for those who are less prepared. Replacing the current simple rating scheme with a complex matrix may also add an administrative burden to the distribution process undertaken by the insurers and their agents.

The discussion involves many interested parties, and the Japanese insurance industry is ready to exchange views with a variety of stakeholders to further improve the system.

Another fundamental argument that has long been in place is the fact that not all policyholders understand the demarcation between residential property insurance and Earthquake Insurance. The latter is made available in the form of an endorsement to the former, and not distributed independently. A typical standard residential property insurance policy excludes whatever losses that follow earthquakes, volcanic eruptions or tsunamis. The treatment of losses due to a resultant fire following an earthquake has been the most critical cause of argument. Insurers are therefore held responsible for explaining the earthquake exclusion clause in the solicitation process of the ordinary personal property insurance policy. It is required to obtain the policyholder's consent not to purchase Earthquake Insurance coverage in case the applicant is not willing to purchase the said coverage. With the co-operation of the agents who deal face-to-face with the policyholders, the number of complaints for lack of explanation appears to be decreasing, but continuous efforts are needed to avoid misunderstandings.

The discussion so far has focused on residential property coverage, but there were numerous automobiles which were carried away by the tsunami. Unfortunately, the vast majority of the vehicle losses were not covered. Only a limited number of policyholders had earthquake, volcanic eruption and tsunami endorsement. Insurers received criticisms for not recommending the endorsement at the time of policy inception. Having heard the voices, the industry has taken steps to inform their policyholders of the availability of the option.

5.2. Possible solutions for commercial line policies

In most cases, commercial property and business interruption policies exclude Japanese earthquake risks. Even if there is coverage, it is very likely to accompany a sub-limit. History tells us that commercial earthquake coverage has been extremely difficult to secure, with only a limited number of market players willing to offer capacity for the risk. It is the severity of the risk on one hand, and limited spread on the other, that limits commercial insurers in underwriting a substantial amount of the risk. Needless to say, risk models need further evolution to enhance underwriting capabilities, however, the risk-based pricing for earthquakes is likely to become prohibitive or volatile because of the inevitably limited spread of risk. There does not seem to be a quick fix in terms of the availability of commercial earthquake insurance.

Even if commercial earthquake coverage is in obvious short supply, ways to avert or minimize financial losses can be found through risk assessment or loss prevention expertise held by insurance companies. Typically, large commercial insurance companies are equipped with in-house risk consulting units, which retain seismic experts and accumulation of knowledge on Japanese earthquake risk. Having such experts conduct surveys at earthquake prone facilities and enhance the risk resilience of the operation may become an effective solution to withstand the impact of the next disaster.

6. Towards sustainable and resilient community development

6.1. The industry's outreach efforts to enhance community disaster preparedness

The number of new applications to the Earthquake Insurance coverage between April and September 2011 was approximately 4,360,000, which represented a remarkable 8.2 per cent increase over the same period the year before. The trend describes well the increased public attention towards disaster preparedness. With its expertise on risk management, the insurance industry is facing a stronger than ever expectation to respond to the growing needs of the public in this respect. Among the insurance company staff who were dispatched to the affected areas to assist claim handling, many recognised how the industry was embedded as a part of the social system.

The national budget for the reconstruction efforts was approved by the government in late 2011 as JPY18 trillion (US$225 billion) for the fiscal year 2011-12 combined. The amount translates to seven years worth of budget for the three most heavily impacted Tohoku prefectures, namely Iwate, Miyagi and Fukushima (Nikkei, 2012a). It is not an exaggeration to state that Japan's economic growth is dependent on the recovery of the Tohoku Region. The question is how the private sector can be involved from the planning stage to encourage regional growth. Each prefecture has been holding meetings with the central government, however, setting up or amending rules to suit the local interest is easier said than done. Mismatches between political intentions and local needs were often apparent. Private sector activists are urging the local authorities to recognise the importance of drawing a realistic picture to meet the demographic changes and other aspects unique to the region, which may include disaster resilience. This is where the insurance industry needs to step in and make its expertise available to enhance the community preparedness against potential risks in society, such as preparing hazard maps against tsunami risks, setting evacuation guidelines for earthquake risks, keeping school children protected from traffic accidents, enhancing crime prevention methods, or securing sufficient nursing care services where the community is ageing. By taking part in the early stage of community development, the insurance industry can potentially contribute to building a secure and safer society. It should also help the industry better identify issues unique to the region, which in turn may help tailoring its products and services to meet the local needs.

The 11 March event reminded us of the importance of raising awareness on disaster risk prevention. School children in the Kamaishi City, which is in the coastal area of Iwate Prefecture, will be remembered for performing a role model in safe evacuation. The children had undergone disaster drills which encouraged them to think and act on their own to find the nearest shelter depending on the situation. As a result, all who were in the school when the shake was felt survived the tsunami. The case offers a good lesson on how to react at the very moment catastrophe occurs. It also indicates how children should be educated to help them make appropriate and prompt judgments to react on their own in case of emergency. There is no question that the insurance industry benefits from having a risk-conscious population. Assisting the younger generation to attain disaster preparedness is an area where insurance companies should focus more in the coming days.

There are ongoing global efforts to enhance disaster risk resilience in towns. In parallel to reinforcing the infrastructure and organisational structure of a community, an essential element is to implant a sense of self-responsibility to cope with disaster among the inhabitants.

6.2. The need for in-depth risk research on earthquake and tsunami

As a professional in handling risks, the insurance industry is supposed to know the risk they underwrite better than anyone else. However, in reality, there are so many unknown aspects when it comes to geophysical risks such as earthquakes or tsunamis. The insurance industry has a motive to research further on the nature and patterns of the said risks for two reasons, namely for its own underwriting and for its commitment to society. The 11 March event was accompanied by many unprecedented features, which called for the Japanese government to establish a research group that consists of a hundred academics from leading universities to study methodologies of forecasting Mw 9 class earthquakes (Nikkei, 2012b). The same is true for tsunami risk, and Tohoku University has launched a research programme in conjunction with Tokio Marine & Nichido Fire Insurance (Tokio Marine), and the findings of the study are expected to help not only insurance underwriting, but a broader audience involved in loss prevention activities against tsunami risks (Tohoku University, 2011b).

6.3. Preparing for the next disaster: the importance of archiving

An experience of a catastrophic disaster offers an opportunity to reconsider the effectiveness of the existing disaster prevention and reconstruction measures. In the wake of the March 11 event, an archiving project was launched by Tohoku University, the intellectual centre of the affected region, in conjunction with the Ministry of Education, Culture, Sports, Science and Technology, and the industrial sector, to collect experiences, records, facts and lessons from various social sectors, while monitoring the reconstruction efforts in the affected area (Tohoku University, 2011a). The compiled information is expected to serve the need to enhance preparedness against the next catastrophic disaster which may take place anywhere in Japan. Tokio Marine has been one of the industry participants to support the initiative mainly through mobilising its network of insurance agents, which in many regions function as a catalyst in the local community. As a positive side effect of the activity, it raised awareness of strengths and weaknesses of the existing social system. The archive project is expected to promote two-way communication between the organiser and the users to stimulate growth on each side.

6.4. The importance of demonstrating transparency and accountability

The nuclear power plant accident raised public attention to corporate and institutional governance issues. Much is anticipated from the enhanced transparency to have lessons from the plant accident not only serve to design a framework to ensure safer nuclear plant operation but to remind the broader business community of the importance of integrated and functional risk management. Many experts and policymakers have made reflections on the incident, and shared their views in defining future directions. There are commonalities to the proposals which can be summarised in the following three points:

1. Avoid overreliance on hardware and place more focus on software in terms of emergency measures.

2. Develop an integrated and comprehensive risk management system instead of pursuing partial optimisation.
3. Undertake clear and transparent decision-making and active dissemination of risk information.

Although technical aspects may differ depending on the industry type, the cited principles seem to apply universally across business sectors, institutional or even national bodies. Simple as it is, there is no question that the said principles are an indispensable part of disaster preparedness.

6.5. Engagement with the international disaster risk resilience initiatives and governmental bodies

The series of natural disasters throughout the year 2011 left scars on many parts of the globe. The flooding in Thailand was another reminder of the need for reliable insurance mechanisms in the neighbouring Asian countries. The effectiveness of a pre-funded financial scheme has become a frequently discussed subject among the national governments in Asia (ASEAN Secretariat, 2011).

Designing a government-backed insurance scheme requires a considerable amount of expertise and knowledge, as was the case of the Japanese Earthquake Insurance system, which has been tested for nearly fifty years. Each time a devastating earthquake occurred, the system stirred a national debate, which prompted the government and the private sector to work closely to reach the best solution albeit the existence of many restrictions. The type and intensity of natural disasters varies among the countries, and there is no template for a successful programme that meets the need of all countries. However, experience in evaluating risks, designing funding mechanisms, developing risk sharing schemes between public and private sectors may be of interest to policymakers in disaster-prone nations. The experience of Japan should be made available to those nations in critical need.

6.6. *"Kizuna",* the bonds of friendship

Japanese people chose the word "*kizuna*", bonds of friendship, as the most symbolic expression to illustrate the post-disaster sentiment of the public. It was used by the Japanese government to express its gratitude to the global community who offered financial and humanitarian aid immediately after the event took place.

As the United Nations and its related bodies gear up with their initiatives to develop frameworks for sustainable and resilient economies, the 11 March event offers many elements for consideration. The Japanese insurance industry is ready to offer knowledge and expertise which may help design a national system to enhance resiliency.

The history of Japan is filled with devastating natural disasters. Each experience implanted a sense of reverence for nature in the Japanese mind. There is no way to avoid acts of God, but there has always been something to learn from the aftermath, which often set the stage for a breakthrough. In the wake of 11 March, people in Tohoku demonstrated a strong spirit of cooperation that united the region and spread across Japan. The Japanese insurance industry is called to be a part of the efforts towards a solid and steady reconstruction process.

7. Concluding remarks

The 11 March incident was unprecedented for society in general as well as for the insurance industry in Japan. Nevertheless, no single insurer fell into financial distress. The fact that the largest insurance loss in the history of Japan did not trigger a systemic market failure is attributable to the Earthquake Insurance system which has been discreetly managed jointly by the government and the private sector institutions.

The Earthquake Insurance system for residential properties has been exposed to critical analysis in multiple dimensions over the past half-century. Cumulative discussions manifested in the current programme structure which has proved itself effective in the aftermath of the devastating 11 March incident. Nonetheless, a number of shortcomings have been identified for future consideration, which call for a continuous discussion among the organisers.

11 March drove the public mindset towards disaster preparedness. As the communities affected by the incident make strides in the reconstruction efforts, the insurance industry should find out how it can contribute to the process.

References

ASEAN Secretariat (2011) "World Bank, GFDRR, ASEAN, and UNISDR Cooperate to Strengthen Fiscal Resilience to Natural Disasters Forum Kicks-Off Efforts to Develop Regional Disaster Risk Financing Strategy", News Release, 8 November.

Centre for Research on the Epidemiology of Disasters (CRED) (2012) "Top 10 most important Earthquake (seismic activity) disasters for the period 1990 to 2012 sorted by economic damage costs at the country level" (created on 23 February 2012 through *www.emdat.be/*).

Endo *et al.* (2011) "*Daishinsaigo no Shakaigaku*" [Post-catastrophe Sociology], Kodansha Gendai Sosho.

Editors of "Nihon o Ronten" (2011) "Kyodai Jishin –Ken-i 16 nin no Keikoku" [Massive Earthquake –Warnings by 16 Authorities], Bunshun Shinsho.

Geospatial Information Authority of Japan (2011) "*Tsunami Shinsui Han-i no Tochiriyou-betsu Menseki nitsuite*" [Regarding Landspace per Use on Tsunami Inundation Range], 18 April.

GIAJ (The General Insurance Association of Japan) (2012) "*Higashi Nihon Daishinsai nikakaru Jishin Hoken no Shiharai Kensuu, Kingaku nitsuite*" [Number and Amount of Earthquake Insurance Payments Pertaining to the Great East Japan Earthquake], statistics as of 1 February 2012, GIAJ website (*http://www.sonpo.or.jp/en/*).

GIAJ (2011a) "The GIAJ Chairman's Statement (Translation)", 15 December.

GIAJ (2011b) "*Nihon no Songai Hoken Fakuto Bukku 2011"* [General Insurance in Japan Fact Book 2011], 26 September.

GIAJ, (2011c) "*Jishin Hoken Todoufukenbetsu Setaikanyuuritsu no Suii*" [Earthquake Insurance –Historical Progress in Penetration Rate per Each Prefecture].

GIAJ (2011d) "Progress actions taken by Japanese general insurance industry", News Release, GIAJ website, 22 April, available at *http://www.sonpo.or.jp/en/news/2011/1104_02.html*

GIAJ (2011e) "Further measures to assist the people affected by the earthquakes and tsunamis", News Release, GIAJ website, 23 June, available at *http://www.sonpo.or.jp/en/news/2011/1106_04.html*

GIAJ website (2011f) "*Higashi Nihon Daishinsai niokeru Songaihoken Gyoukai no Torikumi to Kongo nimuketa Kadai*" [How the General Insurance Industry Responded to the Great East Japan Earthquake, and What Needs to Be Considered Further], Annex to the GIAJ Chairman's statement of 15 December, GIAJ website.

GIAJ (2011g) "*Nihon no Songai Hoken Fakuto Bukku 2011*" [General Insurance in Japan Fact Book 2011], 26 September.

Government of Japan (2011) "*Naikakufu Keizai Zaisei HakushoWhite Paper on Economic and Fiscal Policy*" [White Paper on Economic and Fiscal Policy, Cabinet Office], 22 July 2011.

Hatamura, Y. (2011) "*Sotegai" o Sotei seyo!"* [Expect the "Unexpected"!], NHK Shuhppan.

Hirata *et al.* (2011) *Kyodai Jishin Kyodai Tsunami* [Massive Earthquake, Massive Tsunami], Asakawa Shoten.

Investigation Committee on the Accidents at Fukushima Nuclear Power Stations of Tokyo Electric Power Company, (2011) "*Chukan Hokoku*" [The Interim Report] (December 26, 2011)

Japan Earthquake Reinsurance Co. Ltd. (2011), *Annual Report 2011*.

JMA (Japan Meteorological Agency) (2011a) "*Saigaiji Jishin Tsunami Sokuhou*" [Earthquake-Tsunami Disaster Report], 17 August.

JMA (2011b) *http://www.jma.go.jp/jma/kishou/know/whitep/2-1.html*

JMA (2011c) *http://www.seisvol.kishou.go.jp/eq/sourceprocess/event/20110311near.pdf*

Kinyuu Zaisei Jijou (2011) *"Yokin Kyuuzou no Hisaichi Kinnyuu Kikan, Unnyou ni Nayami"* [Rapid Increase in Deposits at Financial Institions in the Disaster Affected Region, Headache to Secure Favourable Returns], 10 October.

Law on Compensation for Nuclear Damage (1961) 7 June 1961, last updated 17 April 2009.

Law on Nuclear Damage Liability Facilitation Fund (2011) 10 August.

Ministry of Economy, Trade and Industry (2011) *"Higashi-nihon Daishinsaigo no Sangyo Jittai Kinkyuu Chousa"* [Emergency Survey Results on the State of Post-Disaster Industry Activities], METI website, 26 April.

National Police Agency (2012) "2011 *Touhoku Chihou Taiheiyouoki Jishin no Higaijoukyou to Keisatsu Sochi*" [2011 Losses and Police Measures from the Tohoku Pacific Ocean Earthquake], 14 February.

National Police Agency (2011) "*2011 Touhoku Chihou Taiheiyouoki Jishin no Higaijoukyou to Keisatsu Sochi*" [2011 Losses and Police Measures from the Tohoku Pacific Ocean Earthquake], 14 February.

Nikkei (2012a) "1*8 Cho-en, Saidai no Zaisei Shutsudou*" [18 Trillion Yen, Biggest Public Spending in History], 22 January.

Nikkei (2012b) "*M9-kyuu Jishin, Kaimei ni Zenryoku*" [Placing Maximum Efforts in Elucidating Magnitude 9 Class Earthquakes], 28 January.

Non-life Insurance Rating Organization of Japan (NLIRO) (2011) Earthquake Insurance in Japan (updated in May 2011)

Seismological Society of Japan (2011) *http://www.zisin.jp/modules/pico/index.php?content_id=127*

Swiss Re (2011a) "Sigma – preliminary estimates for 2011: natural catastrophes and man-made disasters caused economic losses of USD 350 billion and cost insurers USD 108 billion", News Release, 15 December, available at *http://www.swissre.com/media/news_releases/nr_20111215_preliminary_estimates_2011.html*

Swiss Re (2011b) "Natural catastrophes and man-made disasters in 2010", *sigma* No. 1,2011, available at *http://media.swissre.com/documents/sigma1_2011_en.pdf*

Takahashi, Y. (2012) "*Jishin Hoken Seido*" [Earthquake Insurance System], Kinyu Zaisei Jijou

Takenaka *et al*. (2011) "*Nihon Daisaigai no Kyokun –Fukugo Kiki to Risuku Kanri*" [Lessons from Japanese Large-scale Disasters—Catastrophic Compound Loss and Risk Management], *Toyo Keizai Shinpo*.

The Investigation Committee on the Accident at the Fukushima Nuclear Power Stations, (2012) "*Chukan Hokoku*" [Interim Report].

Tohoku University (2011a) "*Tohoku Daigaku niyoru Higashi Nihon Daishinsai Archive Project Michinoku Shinrokuden Honkaku Kadou"* [Full Launch of "*Michinoku Shinrokuden*", an Archive Project on the Great East Japan Earthquake by Tohoku University] News Release, 12 September.

Tohoku University (2011b) "Regarding the Conclusion of Collaboration and Cooperation Agreement Between Tohoku University and Tokio Marine & Nichido Fire Insurance Co., Ltd." News Release, 8 August.

The Wall Street Journal (2012) "Japan Posts 1st Trade Deficit Since 1980", 26 January.

The Wall Street Journal (2011a) "Japan Plots 40-Year Nuclear Cleanup", 22 December.

The Wall Street Journal (2011b) "Japan's tsunami supply chain comeback", 2 August.

The Wall Street Journal (2011c) "Renesas Sees Post-Quake Share Gains", 21 December.

6. Australian floods and their impact on insurance

*Eva Q. Ma, Michael J. Guinery, Peter McCarthy and Rick Shaw**

1. Introduction

Australia has experienced a large number of natural disasters over the past few years, including floods, cyclones and bushfires. Its neighbouring country, New Zealand, has been hit by large earthquakes that caused catastrophic damages in the city of Christchurch.

The recent floods in Queensland and other states have affected thousands of families and businesses. Many have lost their homes, possessions and others their livelihoods. The scale of the catastrophe has led to calls for a workable national solution to deal with flood insurance.

Flooding is one of the most significant perils to which Australia is exposed, accounting for about one third of insured losses from all disasters over 2011 and a substantially higher proportion of the total cost of disasters. As populations in Australia are generally located near water courses or the sea, floods can often affect densely populated cities and towns.

There has been a high level of controversy surrounding insurance coverage for those affected by the floods. Many people were not insured against floods and some of the people who thought they were insured found they were not, because the definition of "flood" in their insurance policy did not cover the particular event to which they were victim. Some insurance policies had a limit on flood payouts, such as A$15,000, to the surprise of policyholders who had not carefully read their policy conditions.

The Australian government instigated a number of inquiries into flood insurance. A standard definition of a flood is in the process of being created to help avoid future confusion over cover for flood in insurance policies. There has been much discussion around the high level of inappropriate development in Australia, particularly around large cities. The extent to which a householder should be held personally responsible for building in a flood plain, given that government approval is needed for development, is currently under dispute. There has also been inappropriate development of existing buildings, which may have been originally built to allow for a potential flood. The classic "Queenslander" house was built high off the ground, and recent decades have seen infilling of ground floors, which were intended to be left vacant. A lot of new houses have been built on concrete slabs, rather than on foundational piers, and engineering modelling indicated that a mere 30 centimetre clearance would make a significant difference to flood losses.

* This article was written for the Actuaries Institute (AI) while the authors were on summer placement with Ernst & Young (E&Y), under the guidance of Peter McCarthy (E&Y) and Rick Shaw (AI).

Changing societal attitudes have also had an impact on the cost to the government of flood losses. Australians had once a sense of self-reliance, especially in rural areas; however, increasing urbanisation has seen a tendency to look to the government to first make decisions about whether building in a particular site is appropriate, and then to expect government compensation if flood losses occur.

Government compensation for disaster losses including floods is a complex area of public policy. Compensation to date has been normally provided for homeowners who either have no insurance cover or for those who have not taken out adequate insurance coverage. This is seen as inequitable by many observers, as it can be seen as rewarding those who do not incur the cost of insurance, thus rewarding risk-taking behaviour.

There has been considerable public debate about the availability and affordability of flood insurance in flood-prone areas. The Insurance Council of Australia (ICA) maintains that any household in Australia has many options for taking out flood insurance, but there is scepticism in consumers' and other groups that flood coverage is available at affordable prices. Up until the 2011 floods, many insurers did not offer flood insurance covering all flood-related events, but many insurers plan to offer this coverage in the future.

There have been many stories in the media about insurance premiums increasing by significant amounts, such as one thousand per cent. These increases in premiums have come about mainly in response to the frequency of natural disasters in such a short period of time, not just the floods. The higher premiums may suggest that the prior premiums did not truly reflect the expected cost of insurance. It becomes a broad societal issue when some parts of society, which are prone to losses, believe that insurance is not available at affordable prices.

The lack of comprehensive flood mapping has been identified as a major issue. Inappropriate development takes place because either adequate flood maps are not available or are ignored. Insurers then respond to this situation by either not offering cover for flood or by significantly increasing premiums for flood. However, increasing information itself is not a panacea: as insurers become more able to reflect an individual's risk, the fundamental insurance principle of pooling losses becomes less prevalent.

It is often those at lower income levels who live in areas prone to disaster, and higher premiums lead to increased levels of under and non-insurance resulting in higher government payouts and further premium increases ensue.

Recently, the floods have had a significant effect on the general insurance industry and this chapter aims to assess these effects by looking at numerous factors associated with flooding. The nature of the events to which Australia is exposed is reviewed and the economic and insured losses are observed throughout the chapter. Insurance schemes are analysed, loss prevention methods are evaluated and we also look towards future improvements.

2. Background

A natural hazard is described as "*a threat of a naturally occurring event that will have an effect on the environment or on people*". These hazards are generally looked upon as random events. Sometimes, the general areas where certain events may happen are known, although which specific area will be affected is a random parameter.

Floods are events that will most likely affect the same areas every time. This means that in the event of a flood, it is highly probable that the impacted area is not random.

Queensland was hard hit by a series of floods that occurred from the end of December 2010 to January 2011, with several separate severe rain events causing a number of rivers to rise over a lengthy period. Three-quarters of the state of Queensland, including the capital city Brisbane, were declared a disaster zone (Brisbane Times, 2011). Queensland, in size, is equal to the combined areas of Germany, France, Spain and Italy. Thousands of residents were forced to evacuate from towns or cities and at least 70 towns and over 200,000 people were affected by the events (BBC News Asia-Pacific, 2010).

Flooding was widespread across Queensland for the entire month, with certain areas being submerged more than once. The floods saw the closure of many roads and highways, which had an impact on the travel industry.

The floods had a material impact on Australia's GDP. Many industries were heavily affected by the floods, in particular, the coal industry.

Heavy rainfall from mid-January 2011 saw major flooding in central and western parts of Victoria. Several heavy rainfall events, including the tropical low that developed from Cyclone Yasi, caused repeated flooding in the already affected areas.

The financial cost from the Victorian floods was a lot less in total than compared to Queensland, but the Victorian floods had a larger financial impact than the bushfires experienced in Victoria in 2009.

In response to the flood events, in Queensland in particular, there have been a number of inquiries by Australian governments. From an insurance perspective the most notable has been the Federal Government's National Disaster Insurance Review (NDIR).

3. Economic and insured loss

The series of floods in 2011 caused severe damages to Australia in terms of direct cost, including the loss of life and asset damages to both privately owned and public assets, in addition to indirect costs such as interruption to business, unemployment and drop in consumer confidence. On 2 February, Cyclone Yasi hit the coast of Northern Queensland. Yasi was the first category 5 cyclone since 1918 and created significant further damage to Queensland, including flooding and wind damage.

The Queensland Government estimated that the total damage to public infrastructure across the state at between A$5 and A$6 billion. There were also significant costs to the economy from production disruptions, particularly in the mining sector, and at the business and household. Adding to this total are the impacts of Cyclone Yasi, which are estimated to have caused around A$800 million in damages, particularly to the road and transport network.

The following paragraphs set out further details of the estimated damage done to Queensland as of January 2011, based on a report from IBIS World (IBIS World, 2011).

The Queensland floods were expected to impact heavily on the mining sector, with sector revenue forecast to drop by A$2.5 billion. The floods causing mine closures and disruption to vital rail and port infrastructure severely affected the coal and mining services industries.

The heavy rainfall, flooding and Cyclone Yasi in Queensland had a significant impact on the Australian agriculture sector, causing losses of up to A$1.6 billion. Cotton, sugarcane, some fruit and vegetables, most notably banana crops and livestock, have suffered severe losses.

In Brisbane the floods significantly affected about 15,000 properties, among which 5,000 were businesses. In Ipswich, a further 3,000 homes and businesses were flooded. The local government estimated that 70,000 to 90,000 km of council roads had been damaged. There has also been flood damage to rail lines and other public infrastructure, including significant damage to the Queensland sewer system.

The cost of construction to replace and repair infrastructures (e.g. restoring power lines, rebuilding roads and bridges, and reinforcing buildings whose foundations were weakened by prolonged submersion) has been estimated at A$10 billion.

The transport sector was estimated to incur a loss of A$467.4 million due to the floods. The loss could be more, depending on the extent of the damages and the time it takes for the agriculture and mining sectors to recover. The floods have caused significant disruption to the operation of ports, rails and highways, which in turn affected the coal export, shipping and trucking industries.

In addition to the impact from the strong Australian dollar, the tourism industry was significantly impacted by the disruption from floods. The industry revenue was expected to decrease by A$590 million.

In Victoria a vast area has been subject to flooding, thousands of rural properties and hundreds of buildings have been affected.

More than 22,000 sheep, 300,000 poultry and almost 600 cattle have been lost (ABC News, 2011). Cost impacts to the agricultural industry are estimated to be up to A$1.5 billion (The Age, 2011).

3.1. Insured loss

At the end of December 2011 the Insurance Council of Australia (ICA) released figures for the insured losses relating to the Queensland and Victorian floods, and Cyclone Yasi. Insurers had received more than 66,000 claims relating to Australian floods, with a total value of A$2.5 billion.

Estimated insured losses		
Flood region	**Number of claims lodged**	**Total value of claims(A$)**
Queensland	58,463	2.4 billion
Victorian	7,952	122 million
TOTAL	66,415	2.5 billion

The ICA's estimates for insured losses from Cyclone Yasi are A$1.33 billion from 72,203 claims lodged.

The ICA Chief Executive said, "*the figures were a sobering reminder of the important role insurance played in helping communities recover from disasters, but creating more* *resilient communities should be a high priority for federal, state and local governments*" (Insurance Council of Australia, 2011).

4. Flood insurance in Australia

4.1. Private insurance in Australia

The three most common causes of floods are flash floods, storm surges and river flooding. To understand how insurance policies for floods are structured, there needs to be clear definitions for each type of flood.

Storm surge

A storm surge is an offshore rise of water usually associated with a low pressure weather system or cyclone. It is difficult to price property insurance for storm surge floods for the following reasons:

- Due to the low incidence rate, there is no standard basis for calculating insurance premiums.
- Exposure depends on the state's willingness to invest in flood control/prevention methods.
- Since only coastal regions are exposed, premiums would need to be extremely high because only people living on the coast would want to purchase these policies; these high prices may not be affordable for the general public.

Flooding caused by storm surge is typically not covered in any insurance policy.

Flash floods

A flash flood is caused by a local storm that can occur anywhere; i.e., it is not location-dependent. This means that chances of anti-selection are reduced, as it is very possible that many people will want these policies on a broad level.

As there is a broader area of exposure, adequate premiums can be calculated, which means that the flood damage caused by flash floods can be insured relatively more easily than in the case of other types of flooding. Protection against flash floods has typically been included in home and contents policies in Australia.

River floods

River floods only happen in certain areas (near river systems, where a river system overflows due to heavy rainfall upstream). This means that only a small portion of people seek this type of cover (Munich Re, 1997).

Up until the Queensland floods of 2011, only a limited number of insurers covered these events and those that did provide cover charged high premiums (especially in high risk areas) that, for most people, were unaffordable. However, many more insurers are in the process of providing cover for these events in the future.

Those insurers that have offered flood insurance have included it in their "home and contents" policy. One large Australian insurer received over 100,000 claims due to the events (Brisbane Times, 2011b).

As noted above, until the Queensland floods, many insurers did not cover for riverine flood events in Australia, for a number of reasons. Reasons included many deeming it too risky to do so, due to the high exposures, the lack of comprehensive flood maps and the unaffordable nature of offering the cover in high risk areas. One of Australia's largest insurers with a significant exposure to Queensland did offer automatic flood cover in its "home and contents" policies (SunCorp Insurance, 2011).

Many local councils have developed flood maps for their areas. Part of the reason that private insurers are not willing to offer cover is that these maps are not being publicly released, which means that they cannot assess the risk of flood. In addition, some of the available maps are not detailed enough to adequately price insurance cover for floods.

Many insurers only cover flash floods, which resulted in disputes between policyholders and insurers. There was much media coverage of people who assumed they were covered for floods when they were not (RNMA Insurance, 2011). Some of the flooding in Queensland was caused by flash floods, although the majority was from riverine flooding. A major insurer refused to pay some claims in Victoria when damage was found to be from flooding rather than storm. The company has commented that there is not always enough information to comprehensively insure against flooding (The Courier-Mail, 2011).

4.2. Public insurance in Australia

Australia does not have a public insurance scheme in place to deal with losses from floods. The National Disaster Insurance Review, instigated by the Australian Government after the 2011 floods, considered the possibility of establishing a national insurer or reinsurer, and researched flood insurance arrangements in place in other countries. The review recommended that such a pool be set up to address the unaffordability of flood insurance premiums in high-risk flood-prone areas. The federal government in its response to the review appears to have rejected this recommendation (Government of Australia, 2011).

The Actuaries Institute has recommended that a national pool be created for a period of ten to 15 years to subsidise the unaffordable cost of insurance premiums for people who are situated in high-risk flood-prone areas. The premium subsidies are proposed to be contingent on local and state councils undertaking risk mitigation to reduce the financial impact of floods over this period, so that over time fewer properties be subject to flood risk. Other parties like the Insurance Council of Australia have made similar proposals.

Various options exist to fund the pool, including through tax payer levies, a modest premium increase for everybody insured and/or through direct government funding. It is important that the operation of the pool provides incentives to reduce exposure to floods and risk-taking behaviour.

The Australian government has a formal system in place to compensate states for natural disaster losses in relation to public infrastructure. The system is under review as the current arrangements provide few incentives for the states to implement risk mitigation measures including taking out their own insurance cover.

In addition, there has been a practice of the Federal Government providing compensation to individuals for losses arising from natural disasters. In the case of the 2011 floods, the losses were so significant that the Federal Government applied a levy to all taxpayers to fund the cost of the compensation associated with flood payments.

Flood mapping in Australia is scanty and piecemeal. Some attempts have been made by insurers and others to develop comprehensive flood maps. There is a significant amount of investigation being undertaken, exploring the cost and structure of national flood maps in response to the 2011 floods and subsequent government inquiries.

5. Loss prevention approaches

The issues in flood mitigation can be split into future development of new homes and areas, and further development of existing buildings situated in flood-prone areas, plus the current exposure.

To prevent losses, councils need to stop allowing development in inappropriate areas, which can be difficult due to pressure to release new land for housing.

It is relatively easier to stop buildings in new areas as opposed to development in existing areas. For existing buildings, it is easier to turn a blind eye and allow further construction. There are a number of options to reduce the risk of flood damage to existing buildings, as described below.

One approach, which is being adopted to a very limited extent, is for governments to buy back old buildings that are situated in very high-risk flood-prone areas or to compensate people to relocate, although this is a difficult task.

Increasing the capacity of dams is a structural mitigation method that would mean that more rain would be required before floods were to occur. Use of dams could be improved for example by reducing dam levels before wet seasons or forecast times of heavy rain. This has recently been implemented in Queensland for the 2012 wet season. This, in turn, would also allow insurers to re-assess the cost of floods occurring and then possibly offer cover at a lower price.

Planning measures are another mitigation step that can reduce risk. It is up to local councils to decide how much activity goes on in flood-prone areas, as well as what type of construction can take place. For example, revising building codes by requiring buildings to be built by a certain amount above ground (e.g. 30 cm) could significantly reduce the cost of floods in many areas. Flood levees have been used successfully in a number of country towns to reduce flood damage.

The more time and money spent in mitigation means that future economic and social recovery costs will be less in the event of a disaster (Gold Coast City Council, 2011).

These preventive methods can potentially help private insurers charge more affordable premiums for flood cover. It is important that these preventive methods be continually reviewed and updated, as climate change threatens to increase the frequency of natural disasters. Greater probability of disasters means that insurers may find it even more difficult to accurately price policies for potential disasters. If mitigation methods are not up to date, then there are chances of greater damage.

6. Consequence of flood events on the Australian insurance market

Insurers in Australia were hit hard by the 2011 floods, where the effects were felt in the short and long run. Suncorp was the most heavily affected insurer, as it holds the largest market share in Queensland.

After the run of disasters during the last few years, there have been some significant increases in insurance premiums, especially in areas where the exposure to disasters is more pronounced. Some premiums have increased by very significant amounts.

Insurers have been busy repricing their products to allow for a better understanding of the cost of natural perils by using recent experiences. Most insurers have been investing considerable time and effort in developing flood cover and pricing it for householder policies, with many insurers planning to offer this cover for the first time in 2012.

Reinsurers have also been impacted financially by the many disasters in the last few years and have increased reinsurance premium rates, which insurers are passing through to consumers.

Unaffordable insurance premiums for floods in high-risk flood-prone areas remain a significant and unresolved issue. While there is much discussion of flood risk, mitigation developments have been slow. Australian individuals, businesses and insurers will continue to suffer significant financial loss from future floods unless there are major steps to mitigate flood risks and to provide affordable insurance premiums for floods. This has put pressure on governments to find solutions, especially as some householders felt they relied on government approval to build on land which is flood-prone.

7. National disaster insurance review recommendations

In late 2011, the Federal Government responded to the recommendations of the National Disaster Insurance Review and issued a number of discussion papers on a range of issues.

The following paragraphs set out the main issues in relation to flood and include the Government's response and current developments.

7.1. Non–insurance

The problem of non–insurance exists for many different disaster events, not just for flood. For flood, the following reasons for non-insurance for this peril are the following:

- Some homeowners simply choose not to purchase insurance cover for any losses including flood.
- In many situations insurers do not provide flood cover.
- Some policyholders find out after an event that they have only partial flood cover.

To address the issues of non-insurance for flood, the Federal Government is considering the following recommendations from the Natural Disaster Insurance Review, to improve availability and transparency:

- All home insurance policies are required to offer flood cover, but consumers can choose to "opt out" of this cover.
- Introducing a Key Facts Sheet, to be provided by insurers in addition to the existing disclosure documents, to set out key information relating to home building and home content insurance policies.
- Introducing a standard definition of flood that all insurers will be required to offer if the word "flood" is used in policies.

The proposed definition for flood, which is still in draft as the government consults with stakeholders, is:

> *"The word 'flood' means the covering of normally dry land by water that has escaped or been released from the normal confines any of the following:*
> *(a) a lake (whether or not it has been altered or modified);*
> *(b) a river (whether or not it has been altered or modified);*
> *(c) a creek (whether or not it has been altered or modified);*
> *(d) another natural watercourse (whether or not it has been altered or modified);*
> *(e) a reservoir;*
> *(f) a canal;*
> *(g) a dam."*

While a standard definition of floods is a significant step forward, it does not address situations where householders do not purchase any insurance cover or where insurers decide not to offer cover for floods.

Under-insurance

The problem of under-insurance has become more visible since recent natural disasters which caused many homes to be total losses. A good portion of homeowners who purchased home insurance found their sum insured was inadequate and remained out of pocket when rebuilding their house and its contents (excluding any government grants or charity donations).

There are two main reasons for under-insurance:

- Firstly, a homeowner may deliberately choose a lower sum insured to obtain a lower premium; and
- Secondly, it is difficult to estimate rebuilding costs and keeping them up to date. The homeowners may underestimate the cost, resulting in an insufficient level of sum insured.

Insurers currently provide consumers with guidance and tools to assist consumers in estimating an appropriate sum insured.

The majority of insurers in Australia only offer sum insured cover in the home building policies, as opposed to replacement value cover. Under replacement value cover, the insurance companies commit to replace the destroyed home regardless of the cost involved.

The NDIR recommended the transition of the current sum insured cover to replacement value cover, which is more efficient for the recovery of individual losses and beneficial to the community. It believed that although it will take time for the insurers to make the transition, the overall benefits justify the change.

The Federal Government has asked the insurance industry to examine the recommendation and advise the government of its response by the end of February 2012.

National Reinsurance Pool

The government and insurance market are currently facing and seeking solutions to the issue of affordability of flood cover. The problem arises from the fact that there are approximately 6.6 million detached houses in Australia and around 1 to 2 million other dwellings, including terrace houses and home units, but perhaps only 5 per cent to 10 per cent of dwellings are subject to flood risk, or approximately 450,000 houses along with approximately 100,000 apartments. A much smaller number of this population is exposed to a high risk of flood damage. Flood cover for those homes with a high flood risk can result in high insurance premiums, leading to affordability problems.

The NDIR recommended the introduction of a flood insurance premium discount system. Under the recommendation, the premium subsidies would come from a temporary national reinsurance pool, facilitated by the Federal Government. The two primary functions of the pool are:

- *"To deliver discounts to home, contents and home unit insurance policies for eligible properties; and,*
- *To provide flood reinsurance capacity to the insurance market."* (NDIR, 2011)

The Federal Government is considering this recommendation. Solutions to unaffordable flood cover remain have yet to be found.

7.2. Nationally consistent flood mapping in Australia

As recommended by NDIR, the agency sponsored by the Federal Government to operate the reinsurance pool would also undertake national flood risk management, including the coordination of flood mapping across Australia.

To price flood insurance effectively, more comprehensive flood maps are needed. Better flood risk information will also benefit the community in managing the flood risks they face. This will need to be allied with three dimensional water flow modelling to allow for the build environment and encourage appropriate building standards.

The government, in its response to the NDIR report, supports the need for better coordination of flood risk information and the improved public availability of this information, by providing for a central national access point for all existing flood risk information, and will consult with relevant parties on the need for national coordination of flood risk management.

References

ABC News (2011) "Flood levee may have been tampered with", updated 28 January 2011, available at *http://www.abc.net.au/news/2011-01-28/flood-levee-may-have-been-tampered-with/1921882*

BBC News Asia-Pacific (2010) "Australia: Queensland floods spur more evacuations", 31 December, available at *http://www.bbc.co.uk/news/world-asia-pacific-12097280*

Brisbane Times (2011a) "Three-quarters of Queensland a disaster zone", 11 January, available at *http://www.brisbanetimes.com.au/environment/weather/threequarters-of-queensland-a-disaster-zone-20110111-19mf8.html*

Brisbane Times (2011b) "Insurers have 'no excuses': Suncorp boss", 17 February, available at *http://www.brisbanetimes.com.au/business/insurers-have-no-excuses-suncorp-boss-20110217-1axz6.html*

Gold Coast City Council (2011) "Flood mitigation", available at *http://www.goldcoast.qld.gov.au/t_standard2.aspx?pid=1878*

Government of Australia (2011) *Government's Response to Natural Disaster Insurance Review (NDIR) Recommendations*, available at *http://www.treasury.gov.au/documents/2226/PDF/Gov_responseNDIR.pdf*

IBIS World (2011) *Queensland Flood: the Economic Impact, Special Report,* January.

Insurance Council of Australia (2011) "Cost of 2011 catastrophe's passes $4.3 billion as builders take a break", 21 December, available at *http://www.insurancecouncil.com.au/media/57214/cost-of-catastrophes-passes-$4.3b-as-builders-take-a-break-final.pdf*

Le Courier-Mail (2011) "Insurer QBE calls for better mapping of flood zones", 6 April, available at *http://www.couriermail.com.au/business/insurer-qbe-calls-for-better-mapping-of-flood-zones/story-e6freqmx-1226034273911*

Munich Re (1997) *Flooding and insurance*, Munich: Munich Re.

NDIR (2011) *Natural Disaster Insurance Review—Inquiry into flood insurance and related matters*, available at *http://www.ndir.gov.au/content/Content.aspx?doc=home.htm*

RNMA Insurance (2011) *Flood cover in NSW, the ACT and Tasmania — Home, Landlord and Strata Title Insurance*, available at *http://www.nrma.com.au/home-insurance/flood-cover-nsw.shtml*

SunCorp Insurance (2012) "SunCorp Flood Cover", available at *http://www.suncorp.com.au/insurance/home-contents-insurance/flood*

The Age (2011) "Victorian damage bill to hit $2bn", 26 January, available at *http://www.theage.com.au/victoria/victorian-damage-bill-to-hit-2bn-20110125-1a4cf.html*

7. The Christchurch earthquakes of 2010 and 2011

Robert Muir-Woods

1. Introduction

Although the islands of New Zealand are located on a major tectonic plate, they had enjoyed a period of almost 70 years without experiencing a highly damaging earthquake in the vicinity of an extensive concentration of exposure. This situation has dramatically changed as a result of a sequence of earthquakes in and around the city of Christchurch, South Island, New Zealand. The sequence began with the 4 September 2010 Magnitude 7.1 Darfield earthquake, located 40km to the west of Christchurch, on an east-west fault, which had not previously been identified and intersected roads and rivers, with more than 30m of horizontal displacement. On its own, given the very high earthquake insurance density in New Zealand, and the susceptibility of the older buildings, which had not experienced damaging earthquake shaking for more than a century, this earthquake would have presented a significant multi-billion dollar insured loss. However it was what was triggered by this initial earthquake that proved far more material both in terms of loss of life and economic costs. The earthquake initiated a series of aftershocks that migrated to the east closer to Christchurch; and then on 22 February 2011, it triggered a shallow M6.3 reverse fault earthquake directly underneath the city that caused enormous amounts of damage to buildings, as well as major loss of life in the collapse of two older reinforced concrete buildings in the city centre. Even more challenging was the way in which the sequence of damaging earthquakes continued, even as the city was focused on its recovery and restoration.

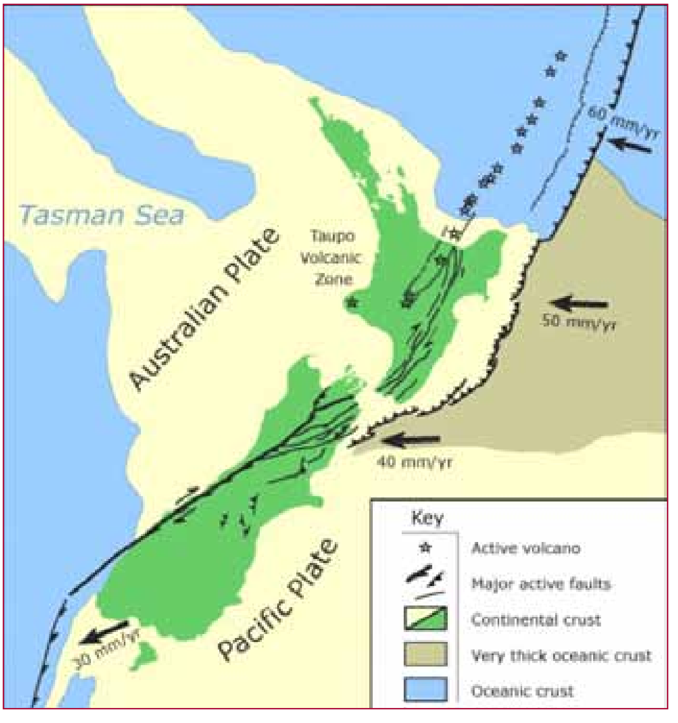
2. New Zealand—tectonic setting

The islands of New Zealand have been formed by the collision between the Australasian plate to the northwest and the Pacific plate to the southeast (see Fig. 1). The city of Auckland on the Australasian plate is currently moving at around 5cm/year relative to Christchurch on the Pacific plate. However the north-east/south-west plate boundary through New Zealand is complex, as the oceanic subduction along the plate boundary switches “polarity”.

To the northeast, the plate boundary is a subduction zone in which the oceanic crust of the Pacific plate goes under the continental crust of the Australasian plate in the Hikurangi Margin to the east of North Island. At the far southwestern end of South Island, the direction of subduction has switched, so it is the oceanic crust of the Australasian plate that dips down beneath the continental crust that is now attached to the Pacific plate.

The zone in between these two subduction zones includes a major north-east/south-west strike-slip fault zone, the Alpine Fault, that runs along the northern side of South Island and that has concentrated around 30mm/year (about 75 per cent) of the overall plate boundary deformation in the region. The southern part of South Island has moved at least 480km south relative to the northern part within the past 25 million years. However to the east of the Alpine Fault, there is a splay of strike slip and reverse faults in the Marlborough and Southern Alps regions (to the northwestern edge of South Island) that carry the rest of the plate boundary motion and that pass into a broad zone of deformation along the southeastern edge of North Island which links up with the subduction zone to the northeast.

Fig 1: Tectonic map of New Zealand



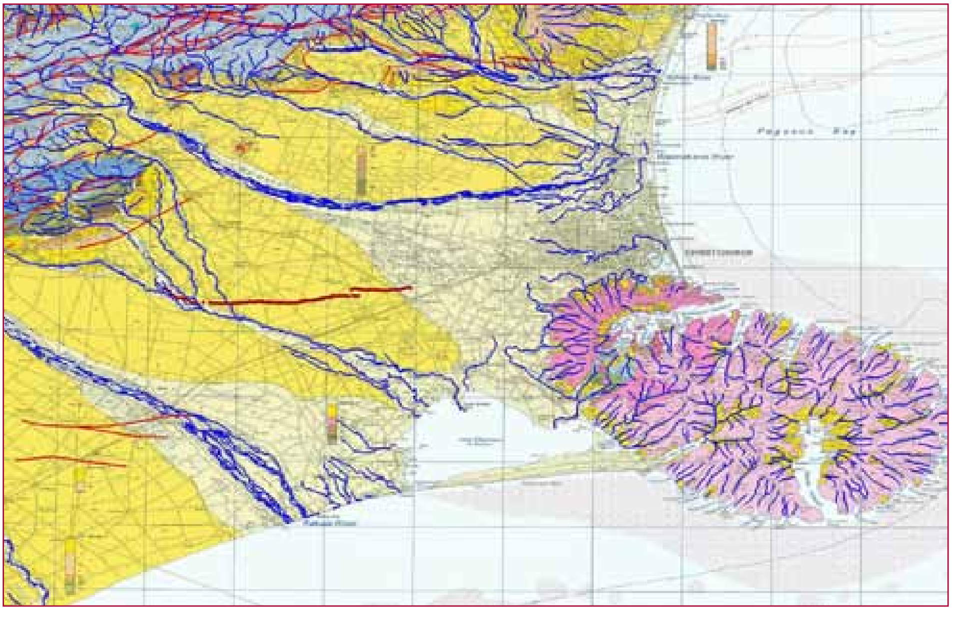
Source: http://www.infohelp.co.nz/pix/PlanetWareNZ1.jpg

3. City of Christchurch

Christchurch, with a population of 376,700 (as of June 2010), was the largest city in South Island, second only to Auckland in New Zealand. The city was founded in the mid 19th century close to an excellent natural harbour at Lyttleton, within the eroded crater of a large volcanic complex on the Banks Peninsula (active between 11 and six million years ago). As the harbour at Lyttleton was surrounded by steep slopes, the city that accompanied the harbour was developed on the Canterbury Plains immediately to the north, on the edge of coastal marshes, and linked to the harbour by a rail tunnel in 1867 and a road tunnel from 1964.

The Canterbury Plains are comprised of recent sediments that had been deposited by braided rivers emerging off the rapidly uplifting and eroding southern Alps (Brown *et al.,* 1995). These recent sediments extend down to a depth of around 500m below the centre of the city, and comprise interlayered deposits of sands, silts and occasional peat layers, as well as coarse gravel lenses reflecting flooding episodes. The centre of the original city was situated on the edge of coastal marshland to the east in which the sediment had been deposited in low energy coastal lagoons and was therefore highly unconsolidated. On the western side, the sediments comprise alluvial sands and gravels laid down by rivers, although below the surface there may also be deposits that were laid down in former coastal lagoons. Across the whole area there is a high water table reaching close to the surface, with streams flowing through the gravels and sands underground (see Fig. 2).

Fig 2: Geology of the Christchurch region



Source: *http://4.bp.blogspot.com/-VDbekZphQ2I/Tbd7AsM7UII/AAAAAAAAAWk/mmv86DDLJBQ/s1600/Julian_geologyc.jpg*

Note: Pink colours are for the volcanic rocks of the Banks Peninsula, Pale yellow and cream indicate recent alluvial sediments. Rivers are marked in solid blue and the extent of surface faulting in the September 2010 Darfield earthquake is shown in solid red.

Most information is available about the subsurface geology from the city centre (Central Business District), where foundations had to be established for multi-storey buildings. In particular where foundations were piled, the aim was to find a suitable gravel horizon into which to base the pile (Browne and Naish, 2003). However as the gravel layers formed lenses, there were situations where buildings were piled to one depth at the front of the structure, but only half that depth to the rear. Also during piling no attempt was made to find what the nature of the deposits that underlay the gravels was.

As the city developed, the residential suburbs expanded out in all directions from the original centre (now the Central Business District). In particular, the expansion to the east passed into areas which presented a strong and identified risk of liquefaction.[1]

The liquefaction potential of the sediments that underlay the eastern half of Christchurch was well known, in particular when the sediments were disturbed in excavations. In 2004, the Christchurch City Council produced a detailed map of the risk of liquefaction across the city, showing that the eastern part of the Central Business District and the whole northeastern sector of the suburbs were situated in areas of high liquefaction potential (Environment Canterbury, 2004 and 2011). It is understood that the City Council even went to court to try, unsuccessfully, to block residential development in some of these eastern suburbs.

4. Earthquake history of Christchurch

Since 1853, around ten earthquakes have shaken Christchurch City (Natural Hazards Research Platform, 2011) strongly enough to cause some individual chimney and minor building damage, at intensities of Modified Mercalli Intensity VI. Only one earthquake on 5 June 1869 is known to have caused pervasive building and chimney damage throughout the Central Business District and eastern suburbs of Avonside, Linwood, Fendalton and Papanui, with intensities up to MMI VII. Outside the city, intensities rapidly decreased, reaching MMI V at Kaiapoi and Halswell, implying a source directly beneath the city. However, a few chimneys and household contents were damaged at Lyttelton. The short duration of shaking is consistent with small (probably magnitude 4-5) local source. In 1901 a moderate magnitude earthquake M6.9 at a regional distance (Cheviot,100km to the northeast) created liquefaction in Kaiapoi to the north-east of the city.

In a study undertaken in 1991 the New Zealand Earthquake Commission claimed that earthquakes with a MMI intensity of VIII, would be expected in Christchurch, on average every 55 years (Elder *et al.,* 1991). The study also highlighted the way that liquefaction could be expected to exacerbate damages, including to water and sewerage systems.

5. Earthquake insurance in New Zealand

The history of the development of earthquake insurance in New Zealand starts with a wave of major earthquakes that swept across the country from 1929 until 1942 (GeoNet, 2011a). The most impactful of the sequence was the Hawkes Bay M7.8 earthquake

1 Liquefaction occurs in an unconsolidated, water saturated, near-surface, sandy sediment deposit when the particles of sand become disturbed—as by vibration—to become more closely packed. This reduces the space between the grains and consequently raises the pressure of the interstitial water. The over-pressured water first forces the particles apart, so that the medium no longer behaves like a solid—with loads carried by the contacts between the sand grains—and instead behaves as a liquid and can flow. High water pressures also force the opening of fissures up to the surface where the sediment-laden water creates characteristic sand volcano features. While the sediment is in a liquid state, if there is a surface slope, or there are variable surface loads (as from a building), then the overburden will move laterally on the liquid layer. The flow of water and sand to the surface causes consolidation, so that once the excess water pressure has been relieved and the sediment returns to being a solid, the original surface will have subsided. The lateral movement of the sediment and the differential consolidation can cause major damage to buildings, and close to a river may also leave the building more prone to flooding.

of February 1931 which destroyed almost all the buildings in the cities of Napier and Hastings and killed more than 250 people.

Following the Napier earthquake, and based on developments in California, a committee was established to propose new forms of earthquake-resistant construction, which became codified in the 1935 Building Code (Davenport, 2004). One of the final events of the earthquake sequence that had begun in 1929 was the Wairapapa quake of 1942 which caused damage in the city of Wellington. Damage took a long time to be repaired, principally because of the shortage of funds and the diversion of attention to participating in the War. After the post-war election, the Labour Government created an "Earthquake and War Damage Commission" (Earthquake Commission, 2012a) to provide public insurance for both earthquakes and war damage to residential properties. Later the coverage was extended to a wider range of natural catastrophes, including landslips, volcanic eruptions, hydrothermal activity, tsunamis and storms or floods, as well as fires caused by any of these perils.

The Earthquake Commission (EQC) policy is a universal addition to a fire policy acquired through a private insurer and covers dwellings and contents (including most forms of personal property, but excluding vehicles and art). The policy is unusual as it also provides coverage for damage to the land beneath and immediately around a dwelling, as well as along access ways to the property. However the policy does not cover the costs of Alternative Living Expenses. The cost was NZ5c for every NZ$100 insured, with a maximum per household of NZ $67.50 per property (the initial premium charged when the scheme was set up after WWII was NZ25c). Cover extends up to NZ$100,000 for buildings and NZ$20,000 for contents, while there is no limit for restoring land damage. The underlying residential insurance policy covers other forms of loss, such as fire or burst pipes, as well as items not covered under the EQC policy such as external buildings, walls and swimming pools, as well as losses beyond the EQC policy limit. Commercial properties are not covered by the EQC and take out private earthquake insurance as an extension to fire policies, which are widely available. Earthquake insurance take up rates in New Zealand have traditionally been very high. The EQC policy for buildings is taken by approximately 95 per cent of homeowners in New Zealand while 70 per cent also take the contents cover.

At the start of 2010, the EQC had reserves of NZ$5.6bn (Earthquake Commission, 2010) backed up by "excess of loss" reinsurance covers, which provided a layer of NZ$2.5bn of coverage above a NZ$1.5bn deductible. After a first loss and reinstatement of the premium the deductible reduces to NZ$1bn. The EQC is ultimately backed by government guarantee.

The private insurance market is concentrated and the five largest insurers control three quarters of the non-life market: Insurance Australia Group (NZ) Holdings Ltd., Vero Insurance New Zealand Ltd., AMI Insurance Ltd., Lumley General Insurance (NZ) and Tower Insurance Ltd. Other companies active in the market include: Allianz, Ace, QBE, Chartis, Zurich, FM Global, Ansvar (Ecclesiastic) and Offshore Market Placement at Lloyds. The total value of earthquake insurance premiums in New Zealand for commercial is about 30 per cent higher than the total (EQC and private insurers) for residential.

6. The 4 September 2010 Darfield Earthquake

On 4 September 2010, at 4:35 a.m. local time, a Mw7.0 earthquake struck the South Island of New Zealand, close to the village of Darfield, in the low population Canterbury Plains region, 44 km to the west of Christchurch (GNS Science, 2010).[2] The fault ruptured to the surface and created a complex east-west zone of horizontal displacement, which at intersections of roads and drainage channels showed a ”dextral” offset of 3-4m. The fault trace had not previously been identified and there was no indication that the fault had broken through to the surface in the period of the Holocene (past 10,000 years) since the sediments of this region were deposited.

Widespread damage to unreinforced masonry (URM) chimneys and walls was observed in Christchurch and villages closer to the epicenter, while in the central business district (CBD) of Christchurch, damaged URM walls fell onto empty streets, reflecting shaking intensities assessed as VI to VII on the Modified Mercalli Intensity scale. Strong motions recorded in Christchurch were in the range of 0.15-0.30g (the acceleration of gravity). There was quite widespread liquefaction in Christchurch’s Eastern suburbs, in areas close to the river. The port at Lyttleton also experienced significant damage, in particular from lateral spreading.

7. 22 February 2011 Lyttleton Earthquake

Aftershock activity following the earthquake continued to spread towards the east and on 26 December 2010, there was a swarm of aftershocks directly under the city, the largest with a magnitude of 4.9. On 22 February 2011, at 12:51 p.m. local time, a shallow (5km deep) Mw6.3 earthquake broke at Lyttleton under the southeast corner of the city, with a reverse fault motion that was directed towards the city centre (GeoNet, 2011b). Again the fault on which the earthquake occurred had not been previously identified. This earthquake produced much higher ground motions under the city of Christchurch than the original Darfield ‘mainshock’, especially in the region of the Port Hills, the Central Business District and the eastern suburbs. Ground accelerations of 0.6-1g were measured, while intensities in the city were assessed as MMI VIII+.

8. Earthquakes in June 2011

By the beginning of May 2011, GNS Science then indicated that there was a 25 per cent chance of another event of M6.0 or greater affecting Christchurch or Canterbury during the next year. During the afternoon of 13 June 2011, a M5.6 event occurred, followed by a M6.0 earthquake less than two hours later (GeoNet, 2012), which caused some further damage on the southeast side of the city, including that caused by large boulders falling from cliffs on the edge of the city.

9. Earthquake damage

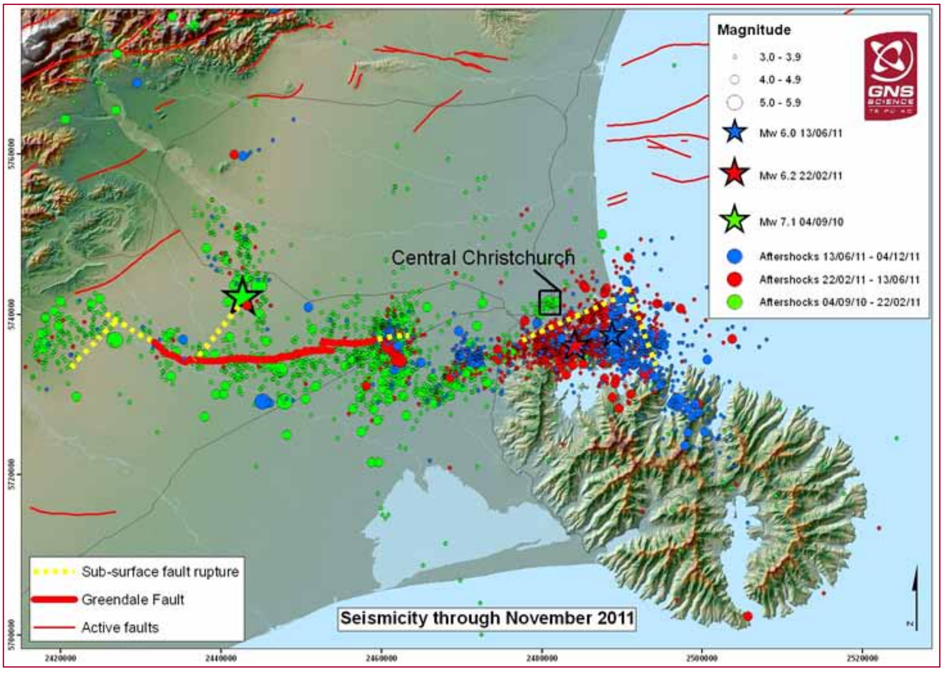
After the February earthquake, there was very widespread damage across the city. A total of 181 people were killed with more than half of these in a single collapse of the six-storey Canterbury Television Building. Other notable collapses included the four-storey

2 Core research and data on earthquakes in New Zealand is provided by GNS Science—formerly the Institute for Geology and Nuclear Sciences—a government-owned company.

reinforced concrete Pyne Gould Corporation headquarters, constructed 1963-64, in which 18 were killed.

Across the city, almost all unreinforced masonry properties, whether small commercial or residential, suffered significant damage or collapse. There was also extremely pronounced liquefaction and corresponding differential land movements across all those areas on the east and northeast side of the city, which proved far more extensive and disruptive than that experienced the previous September. The highest levels of residential building damage were in those neighbourhoods impacted by liquefaction, such as the communities of Shirley and Westhaven. The main drivers of damage in residential areas south and southeast of the CBD were ground shaking, landslides, and rockslides. Steel-framed industrial facilities generally sustained less damage than commercial and residential structures.

Fig 3: Map of main shocks and aftershocks as of end November 2011



Source: *http://www.gns.cri.nz/Home/News-and-Events/Media-Releases/Most-damaging-quake-since-1931/Canterbury-quake/Recent-aftershock-map*

10. Central Business District

In the Central Business District of the city there were many buildings that were found to be out of a vertical axis as a result of differential settlement. Among the most notable examples was the 26-storey Hotel Grand Chancellor—the tallest hotel in the city—which was displaced half a metre and dropped 1m on one side. However around 25 per cent of all the buildings in the CBD were found to be no longer vertical—with tilts of 25mm or greater, the level generally given for "construction tolerance". Such tilting has resulted from areas of liquefaction and consolidation even beneath the layers of gravel into which the buildings were piled.[3]

Those buildings with the largest tilts, such as the Grand Chancellor, were considered potential hazards to all the buildings in their vicinity—justifying the need to establish a general cordon and long-term evacuation of the whole Central Business District.

Within the 71ha CBD, around 50 per cent of the commercial buildings, comprising 900-1000 structures, can be expected to be demolished. At the end of this process there will likely only be 10-15 multi-storey towers remaining. Many of the demolitions will not be because the properties are deemed dangerous but because they are considered uneconomic to repair. Buildings developed since 1982 (when a new improved building code was introduced in New Zealand) have generally survived the earthquake, but also taken significant levels of damage, which means many are considered total losses. In the CBD, there are 50-60 medium size buildings where no decision has yet been taken on whether to demolish or not.

Since 1982 the standard design employed in New Zealand for multi-storey structures has been flexible-moment resistant frame buildings, intended to be flexible and therefore not to attract significant seismic loads. Buildings were intended to survive a “500 year return period event” at that location, but also have safety margins to “withstand a 2,500 year event”—which is considered the equivalent of what was experienced on 22 February 2011 in Christchurch. However, the majority of buildings built since 1982 have turned out to be “beyond repair” as a result of internal damages. For example, ductile reinforcing bars, instead of stretching as intended, were limited by the strength of the surrounding concrete and broke. Stair systems collapsed, shear walls failed and columns and floors ruptured (Earthquake Engineering Research Institute, 2011).

However, most shocking to the people of Christchurch was that two multi-storey office buildings, the 1986 Canterbury Television (CTV) and 1963 Pyne Gould Corporation (PGC) building suffered complete pancake collapse and killed 115 people in the CTV building and 18 in the Pyne Gould building. In these buildings, the floors pulled away from the earthquake-resisting shear core of the structure, which housed the liftwells and staircases, apparently as a result of inadequate detailing linking the floors and walls. Questions are also being asked as to whether these buildings should have been assessed as ‘undamaged’ after the 1st September earthquake.

Building performance in New Zealand, as witnessed in the Christchurch earthquakes, has been compared adversely to the improved lessons and building practice gained from enhancements in structural design in California and Japan.

In particular, it was noted in Christchurch that the small number of stiff and ductile steel frame structures, such as the 12-storey HSBC Club Tower in Worcester St., and the 23-storey Pacific Tower in Gloucester St, had generally performed well. Part of the stiffness of these structures was contributed by composite floor systems in which the floor concrete was poured on to steel decking, supported on a network of steel beams (Earthquake Engineering Research Institute, 2011).

Given that many of the properties were underinsured, but have been able to gain insurance payments for two earthquakes, it also appears likely that building owners have seen the opportunity to renew their building investments, using the insurance payments. For

3 New Zealand Department of Building and Housing (2011).

example, for one hotel, the building value was NZ$60m, while it has cost NZ$10m to demolish the building—combined sums that were only achieved through claiming on both the September 2010 and February 2011 earthquake limits.

A major question concerns what will be permitted to be constructed in the CBD going forward, or even whether building owners will choose to redevelop at this location. That the CBD has been completely closed off for more than 14 months has encouraged a number of commercial developers to focus on creating new low-rise shopping centres and business buildings on the firmer soils at the western edge of the city, close to the airport. There also remains uncertainty about how to avoid foundation problems for taller buildings from future deep liquefaction. A seven-storey height limit is under discussion for the redevelopment of the CBD. However, it is not yet resolved whether a building that is demolished can be rebuilt to its original height—or whether people in Christchurch can even countenance taller buildings. It is already evident that the CBD will not be reinstated at its former density, and therefore the centre of the city may become an area of amenities and open spaces in its place.

11. Insurance response

Following the Darfield earthquake of September 2010, approximately 80-85 per cent of the homes in the region made an insurance claim—a total of more than 157,000 claims (Earthquake Commission, 2012b). The February 2011 Lyttleton event generated an almost identical number of claims, although the claims were distributed more to the east than those of the previous event. Individually, each of these events drew far more claims than any previous event in the New Zealand EQC's 65-year history.

Given that the EQC had only settled a minority of claims before the February earthquake, it was generally assumed that the EQC would lump the costs of repairing the damage from the different earthquakes together when determining what could be paid within the coverage limits. However, on 7 September 2011, the New Zealand High Court announced that the EQC limits on building and contents damages applied to each earthquake, and not to the total loss in the year across all the earthquakes of a sequence. This meant that for the 110,000 properties for which claims had been submitted covering more than one earthquake, separate limits would be applied. The EQC has assessed that this decision would cost them an additional NZ$1bn, although this was also money saved in the costs paid out by the private insurers who had written the original policies and who would otherwise be expected to cover all those losses that fell above a single limit.

12. Land damage claims

Land damage insurance is unique to New Zealand. The experience of the 2010 and 2011 earthquakes will mean a significant reassessment as to how the risk cost associated with the coverage is calculated. After the Darfield earthquake, the EQC concluded that:

> "*The subsurface materials underlying the subject area of Brooklands are assessed to have generally returned to their pre earthquake strength, with the same liquefaction potential as before the earthquake. As such, the continued current residential use and remediation of properties for this subject area is considered technically feasible.... (W)e consider that the risk of land damage due to a future seismic event is sufficiently low that building consents should continue to be issued*

> *for residential developments within the subject area in accordance with existing procedures."*

In September 2010, most land damage was minor, with repairs involving filling, rolling, and smoothing at minimal cost. At the time, the government pledged to remediate the most severely damaged land.

However following the much more widespread damage from the Lyttleton event, it became clear that many properties could not be rebuilt on their former locations, in particular because the sites of the properties had slumped into the floodplains of rivers running through the city's suburbs and were deemed now to be too high risk from flooding to permit building.

The Canterbury Earthquake Recovery Authority (CERA) was established on 29 March 2011 as a stand-alone government department to coordinate the rebuilding and recovery effort of the region (Canterbury Earthquake Recovery Authority, 2012). The Land Zone Maps, as coordinated through CERA[4] have been a very useful tool for the residential property owners to manage the reconstruction process. The red zone includes areas where infrastructure is not economically reasonable to repair and where homes will be demolished (regardless of the state of damages). These homes reside in or are adjacent to areas with high susceptibility to liquefaction. Other zones within the Land Zone Maps include a "green zone", where repair/rebuild process can begin and an "orange zone", where further assessment is required. The red zone currently includes approximately 5,940 homes. As of 8 November 2011, 1,666 properties remained in the orange zone. CERA's intent is to declare certain residential areas as off-limits for development, as the underground infrastructure to support these areas was too badly damaged and will most likely be further damaged if significant liquefaction occurs in a future event.

Roads, power, water and waste water systems have all been damaged significantly in the areas affected by liquefaction, leading to people moving out of their homes. Shortly before the February 2011 event, the government announced a package, independent of the EQC, to support homeowners who had exhausted their Additional Living Expenses (ALE) cover from the September 2010 earthquake (ALE is not a coverage offered by the EQC).

Similarly, the government has spent over NZ$150 million on subsidies for companies and workers who have lost income and jobs due to the February event, with plans to spend an additional NZ$90 million. The decision by the Canterbury Earthquake Recovery Authority (CERA) to deem certain neighbourhoods as "not economically reasonable to repair" is having a profound impact on the recovery process for Christchurch and for the residents of the region.

13. Losses to commercial properties

For commercial claims, loss adjustors who have worked at the city observed the following:

- Sums insured were too low.
- High costs of demolitions and debris removal were not being factored into insured sums. While demand surge has not been identified in reconstruction costs so far, this is principally because building work has been held back, in particular because of the continuing earthquake activity. Inflationary pressures on costs can be anticipated

4 And available at *http://www.landcheck.org.nz/*

once everyone is engaged in rebuilding at the same time. There are also concerns about where a large construction force would stay.

- Inadequacy of professional fees coverages—engineers' fees have seen an escalation.
- Contract wordings have proved problematic around the definition of what constitutes "as new" in defining repairs and upgrades—in particular for older buildings.
- There remains considerable uncertainty about how the rules for upgrading damaged properties will be applied, and whether the level of retrofitting will be consistent with the requirements for future insurability.

The final business interruption (BI) losses are still emerging and are expected to be large for a number of reasons. Businesses whose premises have been destroyed have needed to relocate incurring significant additional costs. Access to the CBD has been prohibited since February 2011, especially for businesses in buildings near the Grand Chancellor Hotel. It is reasonable to assume many BI policies for companies within the core of the CBD near the Christchurch Cathedral and the Grand Chancellor will take limit losses (Barton, 2011). There are also threats of litigation by commercial organisations against their insurers on the basis that they were encouraged to purchase only a year of BI coverage.

While many residents have moved away from Christchurch, more than half the suburbs are functioning fairly normally. Many of the businesses originally located within the CDB cordon have relocated to the suburbs while employees are also working from remote locations where possible. These efforts will help reduce the total costs of interrupted business. Lyttelton Port, which supplies much of the goods for the region, restored critical services within 96 hours of each earthquake in the sequence. Although operational, several facilities, including a number of berths, storage buildings and the administration building are no longer usable and it is expected that the total repair and business interruption costs will amount to the single largest corporate insurance claim in the Southern Hemisphere.

14. Total insurance liabilities

At the end of August 2011, the EQC stated its total liabilities (net of reinsurance recoveries) from the earthquakes to be estimated at NZ$7.1bn, a NZ$4bn increase on earlier estimates (Earthquake Commission, 2011). Including the reinsurance, this would be closer to NZ$11bn. Part of this reflected NZ$1.42bn to cover damage from other aftershocks, including that of 13 June 2011. At the time of the 2011 budget, only 12,000 houses were assessed as having been subject to losses in excess of NZ$100,000, but this number had now risen to 30,000 houses. Land damage was originally assessed as only adding NZ$300m to NZ$600m to the total, but this had now risen to NZ$1.8bn.

It was also stated that at the time of the 2011 budget, the treasury had put the total earthquake damage bill to property owners and insurers at NZ$15bn—representing 8 per cent of the GDP—the worst natural disaster in recent times to hit a developed nation, relative to the size of its economy. The total insurance loss estimate must now be raised to circa NZ$24-28bn (ie: US$17bn), comprising NZ$11-12bn for the EQC, an estimated NZ$10-12bn for losses to the commercial sector and potentially NZ$3-4bn from private insurers covering the 30,000 residential properties with losses in excess of the EQC limit.

At the end of September 2011, having paid out for NZ$700 million of losses including to the Christchurch Anglican and Catholic cathedrals, the Christchurch Arts Centre, and a number of private schools, the British-owned Ansvar Insurance declared it was no longer prepared to offer earthquake coverage nationally.

For the mutual insurer AMI, the second largest insurer in New Zealand, the magnitude of the losses proved beyond their capacity to bear, even taking into consideration their reinsurance. In April 2011, the New Zealand government said that it had agreed to make NZ$500m available to AMI, indicating that it expected this amount would have to rise up to NZ$1bn. AMI had reinsurance cover for the second quake up to NZ$600m. AMI had 85,000 policyholders in Christchurch—reflecting 35 per cent of the residential market.

On 11 October 2011, it was announced that the EQC levy of about NZ$5 per NZ$100 of insured coverage (up to a maximum of NZ$69 per year) would treble from 1 February 2012, to about 15 per NZ$100 of insurance cover up to a maximum of NZ$207 per property. This premium increase was intended to reduce EQC's estimated cash shortfall of NZ$1.2bn to NZ$490m and to begin to rebuild the EQC reserves back to NZ$6bn after an estimated 30 years (on the assumptions that no other significant earthquake losses intervene). The annual levy revenue was assessed as being about NZ$260m.

15. Future earthquake risk in New Zealand

The decision to abandon certain suburbs in Christchurch has reduced the risk of a future earthquake in the city causing comparable levels of liquefaction-related losses in the suburbs. The depopulation of commercial buildings in the CBD should also serve to reduce the overall risk in the city.

Based on their geology, there is no likelihood that such large-scale liquefaction could occur elsewhere under the principal cities of New Zealand, as only very small areas in Wellington and Auckland are mapped as having "very high" liquefaction susceptibility and the cities are not principally situated on recent major river deltas.

However the chief concern for New Zealand going forward will come from the possibility that earthquake activity could return to the levels experienced between 1929 and 1942 when there were seven earthquakes of magnitude seven or greater. Such an eventuality would significantly test the reserve regenerating plans of the EQC.

The lessons from the 2010-2011 earthquakes in New Zealand and the extraordinary levels of damage seen in Christchurch will, however, have profound lessons for considering earthquake risk in a number of other locations around the world.

References

Barton, C. (2011) "Christchurch: Inside the red zone", *New Zealand Herald* , 17 December, from *http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10773670*

Beavan, R.J. (2004) *Kinematics of the New Zealand plate boundary: field report on the 2003 GPS survey of the Central North Island/Taranaki network (CNI2003)*, Institute of Geological & Nuclear Sciences science report 2004/05.

Brown, L.J., Beetham R.D., Paterson B.R. and Weeber J.H. (1995) *Environmental and Engineering Geology*, 1: 427-488.

Browne G.H. and Naish T.R. (2003) "Facies development and sequence architecture of a late Quaternary fluvial-marine transition", *Canterbury Plains and Shelf New Zealand, Sedimentary Geology* 158: 57-86.

Canterbury Earthquake Recovery Authority (2012) available at *http://cera.govt.nz/*

Davenport P.N. (2004) *Review of seismic provisions of historic New Zealand loading codes*, paper presented at the 2004 New Zealand Society of Earthquake Engineering Conference, available at *http://db.nzsee.org.nz/2004/Paper17.pdf*

Earthquake Commission (2012a) available at *http://www.eqc.govt.nz/home.aspx*

Earthquake Commission (2012b) *Canterbury Earthquakes*, available at *http://canterbury.eqc.govt.nz/*

Earthquake Commission (2011) *EQC's earthquake liability revised upwards—Finance Minister Bill English*, EQC News Release (30 August), available at *http://canterbury.eqc.govt.nz/news/release?page=2*

Earthquake Engineering Research Institute (2011) *The M6.3 Christchurch, New Zealand, Earthquake of February 22, 2011*, EERI Special Report, May, pp. 1-16, available at *http://www.eeri.org/site/images/eeri_newsletter/2011_pdf/EERI_NewZealand_EQRpt_web.pdf*

Earthquake Commission (2010) *Earthquake Commission Annual Report 2009-2010*, available at *http://www.eqc.govt.nz/abouteqc/publications/annualreport/2009-2010/highlights-10.aspx*

Elder D.M.G., McCahon I.F. and Yetton M. (1991) *The Earthquake Hazard in Christchurch: a detailed evaluation*, EQC Report, available at *http://www.eqc.govt.nz/home/research/researchpapers.aspx*

Environment Canterbury (2004 and 2011) *The solid facts of Christchurch liquefaction*, available at *http://ecan.govt.nz/publications/General/solid-facts-christchurch-liquefaction.pdf*

GeoNet (2012) "Aftershocks", available at *http://www.geonet.org.nz/canterbury-quakes/aftershocks/*

GeoNet (2011a) "Historic Earthquakes in New Zealand", available at *http://www.geonet.org.nz/earthquake/historic-earthquakes/*

GeoNet (2011b) "M6.3, Christchurch, February 22 2011", available at *http://www.geonet.org.nz/earthquake/historic-earthquakes/top-nz/quake-14.html*

GNS Science (2010) *2010 Darfield (Canterbury) Earthquake,* available at *http://www.gns.cri.nz/Home/News-and-Events/Media-Releases/Most-damaging-quake-since-1931/Canterbury-quake/Darfield-Earthquake*

Natural Hazards Research Platform (2011) "New Zealand's deadliest earthquakes and past earthquakes in Christchurch", available at *http://www.naturalhazards.org.nz/NHRP/Hazard-themes/Geological-Hazards/February-22nd-aftershock/New-Zealand-s-deadliest-earthquakes-and-past-earthquakes-in-Christchurch*

New Zealand Department of Building and Housing (2011) *Structural performance of Christchurch CBD buildings in the 22 February aftershock; Stage 1 Expert Panel Report,* 30 September, Report of an Expert Panel, available at *http://www.dbh.govt.nz/UserFiles/File/Reports/quake-stage1-expert-panel-report.pdf*

8. Blown away: monetary and human impacts of the 2011 U.S. tornadoes

Kevin Simmons, Daniel Sutter and Roger Pielke

1. Introduction

As 2011 began, the big news in the American sports world was the showdown between Auburn and Oregon for the national championship in college football. The big political story was the Tea Party, which had just helped Republicans regain control of the U.S. House of Representatives. In Hollywood, speculation was rife on who would win an Oscar. In other words, 2011 began as most years do. No one foresaw that the first five months of the year would reset the expectations of meteorologists, insurance companies, and the public regarding the toll tornadoes can impose on the U.S. today.

The decades leading up to 2011 convinced many that the tornado threat had been reduced to the point that 100 fatality tornadoes and 500 fatality years were in the past. After all, neither figure had been exceeded in the U.S. in over 50 years. The National Weather Service implemented a nationwide network of Doppler weather radars in the 1990s. Warning lead time doubled, and then almost doubled again, providing sufficient time for families to receive a warning and take shelter. Television stations used sophisticated graphics to cover tornadoes with ever-increasing accuracy. Street level tracking software allowed TV viewers to know the exact location of a tornado and how close it might get to their home. In this environment, a tornado that killed 10 or more people was national news and could grab the attention of the public for days and perhaps weeks. In 1999 one of the most powerful tornadoes ever documented struck a metropolitan area and resulted in 36 deaths, which while tragic, was only a fraction of the toll that might have been expected from a tornado like this at the start of the 20th century. The benchmark for what constituted a major tornado event was much different than 1974, when the 3-4 April "Super Outbreak" killed over 300 people. Things were different now, or so many people thought.

We begin by summarising the damages and fatalities from U.S. tornadoes in 2011. Next, we examine the tornado outbreak as it relates to the historical record. The next section looks at the role that extreme weather played, followed by a discussion of some of the vulnerabilities that are known to increase fatalities from tornadoes. We then consider what can be done to limit damages and fatalities from future tornado outbreaks. Finally, we discuss whether or not this was an event that can be expected to occur again and then we conclude.

2. A summary of tragedies

2.1. Damages

A final tally of the damages sustained from 2011 tornadoes is not complete but will set a record for inflation-adjusted property damage. Both Munich Re and the National Climatic Data Center estimate that overall damages will be about US$23 billion, with something over half that amount being insured. The breakdown by month is reported in Table 1.

Table 1: Breakdown of losses by month

Month	Insured losses	Total losses
April	US$11.bn	US$15.5bn
May	US$4.9bn	US$7.0bn
Total	**US$16bn**	**US$22.5bn**

Source: National Climatic Data Center.

Almost 60 per cent (US$9 billion) of the April losses occurred when over 300 tornadoes struck from the Midwest through the Mid-Atlantic on 27-28 April, with the worst of the outbreak centred on Mississippi, Alabama, Georgia and Tennessee. Most of the May damages occurred when an EF-5 tornado devastated Joplin, Missouri on the 22nd, setting a record for damages from a single tornado. An EF-5 tornado has wind speeds in excess of 200 miles per hour and is the highest rating on the Enhanced Fujita Scale used to rate the intensity of a tornado.[1]

The extensive losses caught many insurers off guard. By July, insurance claims already totalled almost US$7 billion and were expected to eventually exceed US$10 billion and perhaps as much as US$16 billion. In Alabama, Alfa Mutual, the second largest insurer in the state, has announced that it will not renew over 70,000[2] policies as well as increase rates by an average 20 per cent[3] for remaining policyholders to attempt to recover from its losses in the April outbreak.

A tornado is quite different from a hurricane. When a deadly hurricane comes ashore, the wind field is large and will affect thousands of homes. Hurricane damages result from wind, but also from water pushed onshore by the winds. A standard homeowners' policy does not cover rising water, but coverage is available through the National Flood Insurance Program. The National Flood Insurance Program was created by the U.S. Congress, with the National Flood Insurance Act of 1968 to offer residents in flood-prone areas a means to share flood risk via a quasi-insurance mechanism. Most banks require homeowners living in a flood plain to have flood insurance in order to obtain a loan for the home, but for many homeowners the coverage is voluntary. This issue became politically contentious after Hurricane Katrina, when Gulf Coast homeowners found that their insurance policy did not cover water damage.

A tornado is strictly a wind event with wind speeds that can exceed the most powerful hurricane. Damage can be extensive and violent tornadoes will completely destroy even the most permanent homes. But tornadoes are covered by a standard homeowner's policy

1 *http://www.spc.noaa.gov/faq/tornado/ef-scale.html*
2 *http://blog.al.com/live/2011/06/alfa_cuts_alabama_policies_tornadoes.html*
3 *http://blog.al.com/live/2011/09/post_128.html*

in the same way as other hazards such as fire.[4] Most homes are insured and any home with a mortgage is required to carry insurance. Insurance typically would cover repairs up to the insured value of the home. The homeowner would be liable for their deductible, which can vary from policy to policy. Nonetheless homeowners who have not updated their policies find themselves underinsured, thus having to use their own funds to complete repairs or rebuilding costs. Some coastal states have begun experimenting with discounts for construction features that limit damage.[5] The Insurance Institute for Business and Home Safety has its Fortified Home[6] programme to illustrate the types of construction practices that can limit wind damage.

Life insurance would compensate beneficiaries of those insured persons killed by the tornado. But tornado fatalities are a very small percentage of fatalities in the U.S., averaging between 50 and 60 per cent annually over much of the past 50 years. Even when this year is accounted for, the rate of tornado fatalities is exceedingly small compared to other mortal risks—for instance, auto accidents typically result in about 35,000 deaths per year.[7]

For qualified homeowners in Presidential disaster areas,[8] the Federal Emergency Management Agency (FEMA) provides some housing assistance, and loans are available through the Small Business Administration.[9] FEMA is also the lead agency in immediate recovery efforts. Damage to state infrastructure such as road and bridges is paid for from public funds at both the state and national level.

2.2. Fatalities

Damaged or destroyed structures can be rebuilt or repaired, but lives lost and shattered cannot be made whole. At this writing in December, the 2011 death toll stands at 552. Most of the deaths (97 per cent) occurred during April and May, with 86 per cent of these deaths from the 27-28 April outbreak across the Southeast and the Joplin, MO tornado on 22 May. Table 2 reports the fatality totals by month.

Table 2: Fatality total by month

Month	Deaths
February	1
March	1
April	361
May	179
June	4
August	2
November	6*

Source: Storm Prediction Center (*November numbers are preliminary).

4 *http://www.usatoday.com/money/industries/insurance/2011-04-28-tornado-insurance_n.htm*
5 *http://www.smartmoney.com/spend/real-estate/new-incentives-to-stormproof-your-home-1305608405674/*
6 Insurance Institute for Business & Home Safety, *www.ibhs.org*
7 *http://www.census.gov/compendia/statab/2012/tables/12s1103.pdf*
8 Upon receiving a request from a state governor, the U.S. President must declare a county to be a disaster area after the event for residents to qualify for these programmes.
9 *http://www.disasterassistance.gov/disaster-assistance*

The 2011 death toll is more remarkable when compared to recent history. Annual tornado fatalities averaged 57 for the 25 years prior to 2011, with the 100 fatality threshold exceeded only twice (in 1998 and 2008). Recent history certainly justifies a popular perception that tornadoes were not the threat they once were. Modern radar and spotter networks made warning the public seem like a science rather than an art (Smith, 2010). The past year reminds us that nature's awesome force often defies our best efforts to survive.

3. How does this year compare to previous extreme years?

3.1. Damage

As mentioned, 2011 set a record for damage and insured losses from tornadoes. But how does it compare to previous years, and particularly previous extreme seasons? Official statistics have been compiled by the Storm Prediction Center (SPC) in Norman, Oklahoma since 1950, so 60 years of records are available for comparison. We focus on damage over an entire season, as this more readily measures the impact on the insurance and reinsurance markets than individual tornadoes, given that the U.S. experiences over 1,000 tornadoes annually. Grazulis (1993) includes information on significant tornadoes prior to 1950 and includes damage estimates on some of these tornadoes. Brooks and Doswell (2001) use these records to make comparisons of selected tornadoes from before and after 1950. Any attempt at a systematic analysis of damage over a season must begin in 1950.

The damage data require several caveats. Natural hazards damage data are generally of questionable quality (Gall, Borden and Cutter, 2009; Downton, Miller and Pielke, 2005), limiting the precision of any comparisons or patterns we manage to identify. Damage estimates prior to 1996 were reported in order of magnitude intervals, with the lowest bin labelled "0" including tornadoes with zero damage and with unknown damage. Clearly some tornadoes with "0" damage must have resulted in damage based on casualties, path length, and F-scale[10] rating, and the missing damage reports serve to underestimate total damage for a season. The categories continue to the highest "9" with damage in excess of US$500 million. We use the mid-point of each category as the damage level for each tornado, as we have done in Simmons, Sutter and Pielke (2012). Since 1996 damage has been reported in dollar amounts. The SPC archive reports damage in current dollars, and so the damage amounts are adjusted for changes in the price level using the consumer price index.

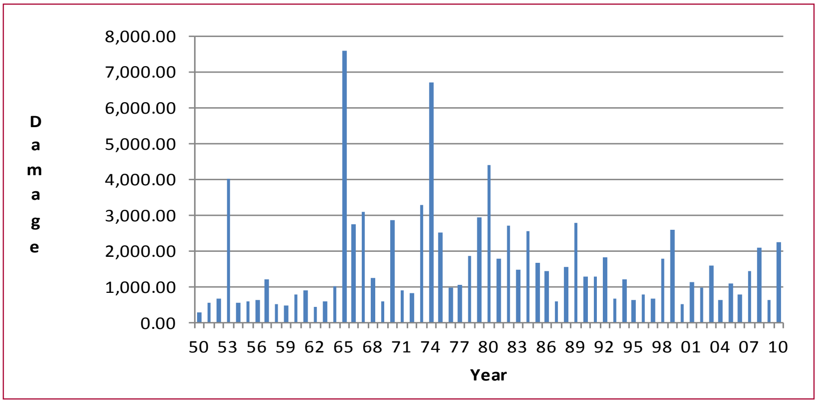
Inflation-adjusted damages have been rising over time for many types of natural hazards, for a number of different reasons. One cause has been increases in population and wealth. The U.S. is a more populated and wealthy nation now than in 1950, and damage is likely going to be higher now than in the past just because there are more people and property which might be in the path of tornadoes. Consequently, inflation-adjusted damage from the 1950s is likely incommensurable with damage in 2011, rendering the historical damage records of limited value. Natural hazards researchers have developed normalisations of damage for population and income or wealth changes (Pielke and Landsea, 1998; Brooks and Doswell, 2001). The normalisations adjust proportionally for changes in population and income, wealth or GDP, so if population doubles, damages are assumed to double as well. The normalisations provide some control for these determinants of damage

10 Fujita Scale in use until 2007. *http://www.spc.noaa.gov/faq/tornado/f-scale.html*

and allow a more meaningful comparison of current and historical damage figures. The normalised data provide a reasonable estimate of damage that might be expected if past tornadoes or tornado seasons occurred today.

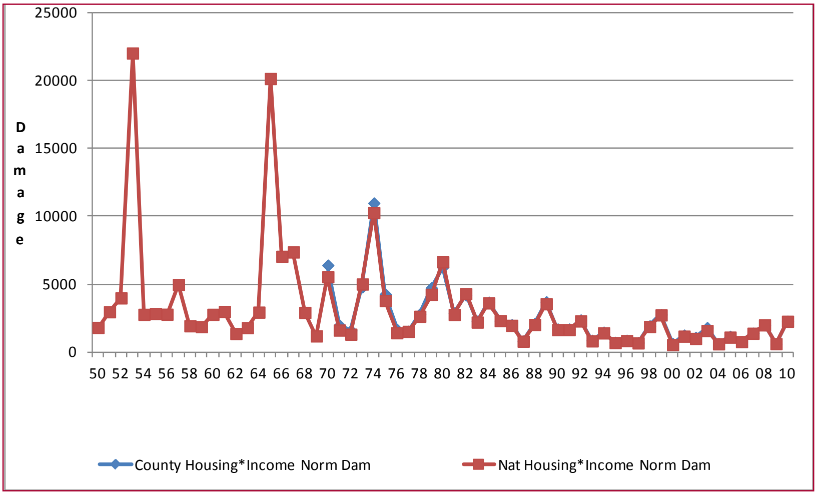
Figure 1 graphs inflation-adjusted damages for 1950-2010, while Figure 2 displays damage normalised for changes in housing and income, in addition to inflation. Both figures illustrate that 2011 was not unprecedented in terms of damage.

Figure 1: Annual damage in price level adjusted dollars, 1950-2010



Source: SPC Tornado Archive.

Figure 2: Annual damage normalised for changes in housing and income, national and county income/housing

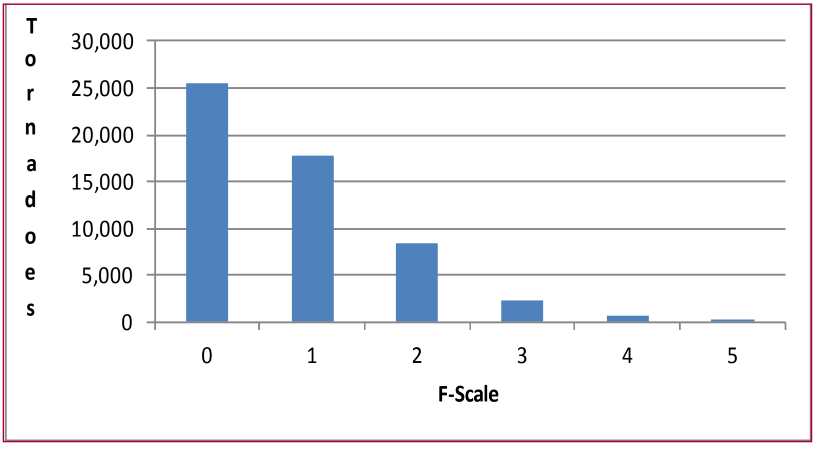


Source: SPC Tornado Archive.

Three previous seasons—1953, 1965 and 1974—now rival damage in 2011. Normalised damage exceeded US$20 billion in 1953 and 1965 and exceeded US$10 billion in 1974. The 1953 season provides perhaps the best historical comparison with 2011, as much of the damage in 1965 and 1974 occurred in just one outbreak. Damage in 1965 is attributable to the Palm Sunday outbreak, while damage in 1974 occurred in the 2-3 April "Super Outbreak". 1953 had multiple damaging outbreaks in different parts of the country. One of the worst tornadoes of 1953 occurred in Worcester, MA, and ranked first in normalised damage until the Joplin tornado of 2011.

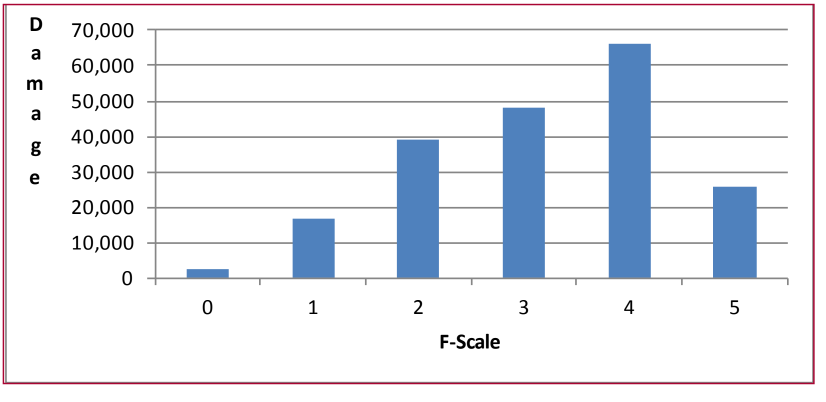
Damage is driven by the intensity of the tornado. While strong and violent (EF-2 and higher) tornadoes represent a small proportion of all tornadoes, they account for the vast majority of damage. Figure 3 shows the occurrence of tornadoes by F-Scale since 1950 while Figure 4 shows total normalised damage by F-Scale over this period.

Figure 3: All tornadoes by F-scale 1950-2010



Source: SPC Tornado Archive.

Figure 4: Housing/income normalized damage by F-scale 1950-2010



Source: SPC Tornado Archive.

The 2011 season featured an unusually large number of "long track strong/violent tornadoes" which contributed substantially to the observed damage. We will discuss these tornadoes further in a later section, but the longer a powerful tornado remains on the ground, the more likely it is to strike populated communities and damage property. Damage is a function of the strength of a tornado, the length of its path, and what lies in its path. As we continue to expand urban areas in regions prone to tornadoes, the likelihood of significant damage will only increase when we have long track, powerful tornadoes.

3.2. Fatalities

2011 was the deadliest year for tornadoes since the start of official records with 552 fatalities, and tied with 1936 as the second most deadly year since 1875. Only 1925, the year of the Tri-State tornado, with 794 deaths, exceeds this year's toll.[11] The 500 fatality threshold has been eclipsed only seven times since 1875 (including 2011). Additionally, 2011 witnessed the deadliest single day (27 April, 320 fatalities) and deadliest single tornado (Joplin MO, 158 fatalities) since the start of official records in 1950.

As discussed above, most of 2011's fatalities occurred in two outbreaks, 27-28 April and the Joplin EF-5 tornado on 22 May. This is consistent with previous years where a handful of tornadoes produced a large proportion of fatalities. An extraordinary death toll requires a long track violent tornado tracking through an area with high population density. The 1953 season was something of an exception to this pattern, as 62 per cent of the 519 deaths came from three tornadoes in different parts of the country. A tornado in Waco, TX, in May killed 114 people, followed in June by 116 deaths in Flint, MI, and 90 in Worcester, MA, on consecutive days. Nonetheless 38 per cent of 1953's fatalities came from other tornadoes throughout the year. The other two years with the highest death tolls since 1950—1965 and 1974—had a higher proportion of deaths in one outbreak. In 1965, 260 of the 301 deaths that year (86 per cent) occurred in the Palm Sunday outbreak, while 80 per cent (290 of 366 fatalities) of 1974's deaths occurred on 3 April. So again we see that high death tolls occur when a violent tornado happens to strike a densely populated area.

4. What role did extreme weather play?

We now consider the role that extreme weather—the number and strength of 2011's tornadoes—played in the season's damage and fatalities. We use the SPC tornado archive as our reference in performing this analysis, which includes over 54,000 recorded tornadoes through 2010. But a quick look at the archive makes it clear that reports of tornadoes in later years were more common than in the early decades of the archive. This makes perfect sense as today we have ways of detecting tornadoes that did not exist 30 or 50 years ago. For instance the annual average of tornadoes during the 1950s was less than 500. The average over the last 20 years is about 1,300. Either tornadoes have become more common, or short track, weak tornadoes are more likely to be reported in recent years. The average number of reported tornadoes increased each decade until the 1990s and since then has remained fairly consistent. Of significance, powerful, long track tornadoes were likely accurately tabulated throughout the years of the record.

As discussed above, damage is largely a product of strong and violent tornadoes. Casualties are similarly concentrated in strong and violent tornadoes. Consequently the annual number of long track strong or violent tornadoes should explain much of the year-to-year variation in casualties and damage. We total the number of long track, strong

11 *http://www.norman.noaa.gov/2009/03/us-annual-tornado-death-tolls-1875-present/*

and violent (LTSV) tornadoes each year since 1950 and the fatalities and damage that occurred in these tornadoes. Specifically we count as an LTSV a tornado with a path length of five miles or more and an EF-scale rating of EF-2 or higher. An average of 89 LTSV tornadoes occurred annually between 1950 and 2010, with a standard deviation of 34. Most years should then see between 57 and 125 LTSV tornadoes; only five years had fewer than 57 and only seven more than 125 LTSV tornadoes. But the seven years with more than 125 LTSV tornadoes include 1974 and 1965. From 1950 to 2010, LTSV tornadoes accounted for 85 per cent of fatalities and 75 per cent of reported damage.

LTSV tornadoes also were important drivers of damage in the other seasons with the most normalised damage. Each of these years had a higher than average number of LTSV tornadoes: 103 in 1953, 144 in 1965, and 175 in 1974. And LTSV tornadoes accounted for at least 92 per cent of reported damage in each of these years.

How active was the 2011 tornado season? To date in 2011 there have been 1,836 tornadoes, which already exceeds the previous annual record of 1,736 in 2008. But of more interest is the number of LTSV tornadoes, which is 178 as of this date, in other words, double the annual average between 1950 and 2010.

As mentioned, only six times over 1950-2010 did the annual total LTSV tornadoes exceed 125, which is one standard deviation greater than the annual mean. The 2011 total also exceeds the highest total observed over this period, 175 in 1974. The 2011 total exceeds the 61 year average by two standard deviations. This suggests that the 2011 season was about a 20 year event for LTSV tornadoes.

LTSV tornadoes alone do not explain death tolls. Examples exist of years with above average numbers of LTSV tornadoes but modest fatality totals and deadly years with few LTSV tornadoes. For instance, 1982 had 142 of LTSV tornadoes, one of the highest totals since 1950, and only 64 deaths, while 1952 had 63 LTSV tornadoes and a death toll of 230, one of the deadliest years over the period. Over 89 per cent of deaths in 1952 were in LTSV tornadoes, demonstrating that the exact paths, timing, and other factors of a year's most dangerous tornadoes matter as well.

5. What role did societal vulnerabilities play?

Extreme weather appears to be the largest contributor to the historic damage and death tolls in 2011. Research (Simmons and Sutter, 2011) has highlighted several factors increasing the lethality of tornadoes casualties, including 1) mobile homes, 2) timing, and 3) region of the U.S. How much of a factor did these vulnerabilities play in the societal impact of the 2011 tornado season?

Manufactured or mobile homes have long been identified as vulnerable to tornadoes. While few site built homes can withstand the winds of a violent tornado, mobile homes are vulnerable to severe damage from weaker tornadoes that may cause only modest or minor damage to a permanent home. Mobile homes comprised 7.6 per cent of the U.S. housing stock in the 2000 Census, but over the years 1995-2010, 43 per cent of tornado fatalities have occurred in mobile homes. So a community with a larger proportion of mobile homes is likely to suffer more fatalities from a given tornado. How much of a role have mobile homes played in the 2011 death toll? Table 3 reports the location of 2011 tornado fatalities.

Table 3: Location of 2011 tornado fatalities

Mobile homes	Permanent homes	Vehicles	Permanent buildings	Outdoors	Unknown	Total
122	209	34	85	8	94	552

Source: Storm Prediction Center.

The location of 94 of the year's 552 fatalities is currently unknown, and determination of where these fatalities occurred could affect inferences about 2011's fatalities. Mobile homes accounted for a smaller proportion of fatalities in 2011 than over the past 25 years. To date 122 deaths are known to have occurred in mobile homes, 22 per cent of all fatalities and 27 per cent of known location fatalities. Even if we assume that all 94 of the unknown location fatalities were in mobile homes, only 39 per cent of 2011 fatalities would have occurred in mobile homes, which is still less than in recent experience. Based on data from the 2010 American Community Survey for housing, mobile homes comprised an average of 16.8 per cent of the housing stock of the path counties from this year's killer tornadoes, which exceeds the proportion of mobile homes nationally. This certainly suggests that the mobile home problem was not responsible for as large a proportion of fatalities in 2011 as in recent years. Mobile homes comprise such a disproportionate share of fatalities because of fatalities in weak and strong tornadoes (EF-3 or less). The likelihood of death in EF-5 tornadoes is approximately equal for permanent and mobile home residents. The number of violent tornadoes in 2011 explains why the proportion of deaths in mobile homes was relatively low.

Timing is an important determinant of tornado fatalities. Tornadoes during the middle of the night, say 2:00 a.m., are not surprisingly more deadly than comparable tornadoes in the middle of the afternoon; everything else equal, expected fatalities are about 75 per cent higher for night-time tornadoes relative to a comparable tornado in the afternoon. The warning response is likely responsible for this difference, as people will be asleep and less likely to receive a warning for a night tornado. But tornadoes after dark do not explain 2011 fatalities. Of the 59 killer tornadoes to date in 2011, only six occurred between midnight and six a.m., with a total of seven fatalities. Nocturnal tornadoes are a known threat and research is needed to address this vulnerability, but it does not explain the 2011 death toll.

The final societal vulnerability that we address is regional differences in fatalities. Fatalities, like tornadoes, are regionally concentrated. The incidence of fatalities is best compared across states as rates per million persons to control for differences in population. Table 4 (adapted from Simmons and Sutter, 2011) reports the 10 states with the highest annual fatality rates over the years 1950 to 2007. For comparison, the U.S. annual fatality rate was 0.4 per million over this period. The states with the highest fatality rates are (in order) Mississippi, Arkansas, Alabama, Kansas, Oklahoma, Tennessee, Indiana, Missouri, Louisiana, and Texas. Table 4 also reports each state's fatality total in 2011.

The worst tornadoes of 2011 occurred in all the wrong places as eight of the states with the highest fatality rates account for 90 per cent of 2011 fatalities. If the outbreaks happened in other parts of the country, would we have seen fewer fatalities? Fatality rates do not allow a conclusive answer because many other factors affect casualties, but regression analysis suggests that expected fatalities are about 25 per cent higher in southeastern states than elsewhere, controlling for a range of tornado and path characteristics. Thus regional vulnerabilities affected 2011 fatalities, particularly in the deadly April outbreaks.

Table 4: Incidence of fatalities across states as rates per million persons

	Fatality rate	2011 fatalities
Mississippi	2.8797	32
Arkansas	2.6966	12
Alabama	1.7230	242
Kansas	1.7014	3
Oklahoma	1.6373	14
Tennessee	1.0727	33
Indiana	.8301	0
Missouri	.7311	158
Louisiana	.7041	1
Texas	.6883	0
Total		**495**

Source: Storm Prediction Center.

6. Can we limit damage and casualties from future outbreaks?

The toll of the 2011 tornado season on persons and property has policymakers, insurers and residents asking the obvious question, "What can we do to prevent more years like 2011?" We turn to this question here.

6.1. Damages

We start with the question of property damage. It would seem that the answer is not much, given the power of tornadoes. While it is possible to engineer a structure to withstand the forces of even a violent tornado, the cost of doing so is prohibitive, particularly for residential construction. Wind engineers have focused on strengthening a small area within a home to save lives. While trying to build homes to withstand violent tornadoes is practically impossible, building techniques designed for hurricanes can help reduce tornado damage. Although violent tornadoes might still destroy strengthened homes directly in their path, we recall that 75 per cent of tornadoes are weak, or rated EF-0 or EF-1 on the Enhanced Fujita Scale. Winds in an EF-1 tornado are estimated to be 110 mph or less, which is within the range of design wind speeds for building codes in coastal areas prone to hurricanes. And all homes in the path of a violent tornado will not experience EF-4 or EF-5 damage. The EF-scale rating for a tornado is by convention based on the maximum damage along the path, and so some portion of the path of a violent tornado will only experience a weak or strong tornado. And not all structures in the path of a tornado at EF-5 strength will suffer EF-5 damage—structures on the edge of a tornado, which might be perhaps a mile wide, might suffer only EF-0 or EF-1 damage. Not every home in the path of a twister is going to be flattened. A study in the aftermath of the April 2011 Tuscaloosa, AL EF-4 tornado documented substantial damage that could have been avoided with improved building techniques.

Builders can adopt construction practices like threaded bolts in the foundation to secure exterior base plates, brackets or hurricane straps to attach exterior walls to roof joists, and use of oriented strand board (OSB) sheathing to increase the structure of the exterior walls. These are some of the same measures included in strengthened wind zone building codes. Some builders are already incorporating such techniques. After the May 1999 tornado outbreak, one Oklahoma City area home builder[12] sought advice from civil engineers at the University of Oklahoma on how to better protect homes from tornadoes. The builder adopted some of the above practices and estimated that the additional cost was about US$500 per home in the early 2000s.

That we can build more tornado and wind resistant homes does not demonstrate the economic case for doing so. An additional cost of US$500 per home might seem modest, but the probability of any home being in a tornado path over its lifetime is low, even in tornado-prone states. While extensive research has been done on damage reductions for strengthened construction in hurricane or straight-line winds, tornado winds produce very different stresses on structures. The data necessary to conduct a rigorous benefit/cost analysis are not available. But available evidence suggests that strengthened construction may be economically viable. Sutter, DeSilva and Kruse (2009) use insurance losses and tax assessor loss estimates from the May 1999 Oklahoma City tornadoes to estimate damage per home by F-scale category. They find that if strengthened construction can reduce losses by one F-scale category, that is, make a home struck by a F2 tornado be damaged as if it had been struck by an F1 tornado, then strengthened construction may be worth the cost, at least in the most tornado-prone states. In addition, strengthened construction should reduce casualties, which would provide additional benefits. Additional research would be needed to establish this point conclusively, but improved construction techniques may help reduce damage and insured losses.

6.2. Fatalities

The National Weather Service has undertaken many steps to help protect the U.S. public from tornadoes over the decades. Important measures include the issuing of formal warnings for tornadoes after 1953, ongoing educational efforts, and the installation of a nationwide network of Doppler weather radars in the 1990s. Warnings now provide sufficient lead time allowing residents to take cover, and permanent homes offer adequate protection from most tornadoes. Sheltering in a closet or bathroom, however, is of limited effectiveness when a violent tornado wipes a home's foundation clear. Since constructing an entire home to withstand an EF-5 tornado is cost prohibitive, engineers have designed "safe rooms" and below ground tornado shelters that can protect residents at a much lower cost. A "safe room" looks like a normal closet or small room but is constructed with walls that will survive a violent tornado. Residents can safely shelter in this room and expect to survive.

Tornado "safe rooms" gained national attention in the aftermath of the 1999 tornado outbreak in central Oklahoma when a family sheltered in their safe room while the rest of their neighbourhood was destroyed.[13] The attention motivated FEMA and the state of Oklahoma to offer subsidies to residents who wanted to install a safe room or outdoor

12 *http://www.homecreations.com/index.cfm?id=1*

13 *http://www.usatoday.com/weather/resources/safety/saferoom.htm*

shelter. The programme was so popular it was oversubscribed (Merrell, Simmons and Sutter, 2002) and spawned other programmes across the region.

Public money has many competing uses, and the funds used to subsidise shelters or safe rooms could be spent on other programmes, including those designed to save lives. Thus, although protecting residents from tornadoes is a worthwhile goal, continued funding of such programmes should only be based on a rigorous benefit/cost analysis. And such an analysis is not favourable to shelters in permanent homes (Simmons and Sutter, 2011). To see this, consider the case of Alabama, which suffered 242 fatalities in 2011. Let us assume that shelters could be provided at a cost of US$2,000 per home. To eliminate permanent home tornado fatalities, shelters would essentially need to be built into all homes in the state. The total cost of shelters is the cost (US$2,000) multiplied by the number of single family homes in the state, estimated at 1.31 million in 2010, for a total cost of US$2.6 billion. Alabama experienced 242 fatalities in 2011, but this thankfully does not occur every year. Since 1950 Alabama has averaged about 10 fatalities per year. Nationally just over 30 per cent of fatalities occur in permanent homes, so shelters in all permanent homes could save 3.1 lives per year. If we assume a 50 year useful life of a shelter and apply a discount rate of 3 per cent, the cost per life saved is almost US$32 million. This exceeds what could be considered an acceptable range for "value of life" (Viscusi and Aldy, 2003).[14] Even in the most tornado-prone states, tornado shelters do not appear to be good public policy investments.

Mobile homes are much more vulnerable to destruction by tornadoes, and the fatality rate for residents of these homes is about 10 times greater than for permanent homes. Because 43 per cent of fatalities occur in mobile homes, shelters in all mobile homes in the state might save 4.3 lives per year and the cost would be much lower because there are only an estimated 243,000 mobile homes in Alabama. The cost per life saved falls to a little over US$4 million, which suggests that government assistance, if offered, should be directed to mobile homes.

Private purchase of shelters is a different issue, however. There is some evidence that shelters increase the value of residential properties (Simmons and Sutter, 2007). This fact, plus the peace of mind that owning a shelter may bring, could encourage many to build a shelter or safe room in their home. But currently, there are few financial incentives for someone to install a safe room such as discounts on insurance rates, and even then the benefit-cost ratio may still be questionable.[15]

7. Can it happen again?

Since 1950, total normalised tornado damage has exceeded US$20 billion three times (1953, 1965, 2011) and US$10 billion one other time (1974). Twice (1953 and 2011) fatalities have exceeded 500. Normalised damage provides a way to make damage from past years comparable to contemporary losses and thus estimate a frequency of loss exceedance. The past suggests that we might expect a US$10 billion damage year once every 15 years and a US$20 billion damage year once every 20 years. Sixty years is not a long enough data series to estimate 100 or 200 year aggregate loss levels. An alternative approach could use GIS (Geographic Information Systems) software to project tornado

14 For a more detailed discussion see Simmons and Sutter (2011).

15 *http://www.smartmoney.com/spend/real-estate/new-incentives-to-stormproof-your-home-1305608405674/*

damage paths onto different areas to estimate the number of buildings which might be damaged or destroyed in a worst-case long track violent tornado. Wurman *et al.* (2007) have done this for major U.S. metropolitan areas and a long track EF-5 tornado which maintained close to its maximum intensity across its path could damage or destroy 40,000 or more buildings in many metro areas. By comparison, the 2011 Joplin tornado damaged or destroyed about 7,500 buildings. Consequently a single tornado resulting in US$10 billion or even US$20 billion cannot be ruled out.

Location is crucial for tornado damage and casualties. If the Joplin tornado had occurred just 20 miles north of its actual path, it would have struck a primarily rural area and would not have produced the greatest property loss of any tornado on record or the highest death toll in over 60 years. But if the path continued to shift north and not 20 miles but 160 miles, the tornado would have struck Kansas City and the damage and casualties could easily have been worse. Damage and casualties depend on exactly where the tornadoes occur, and thus a matter of luck. One factor which appears to increase the likelihood of losses like 2011 in the future is population growth. Since 1950, the population in the 10 states in Table 4 with the highest tornado fatality rates has more than doubled. While a growing population increases the likelihood that a tornado will strike populated areas, the more important factor here is likely suburbanisation. Urban areas have population densities over 1,000 persons per square mile, which can be 100 (or more) times greater than the population density of rural areas. A doubling of population which doubles population density everywhere over 50 years will have little effect on impacts relative to the variation from year to year due to violent tornadoes striking urban or suburban areas. Population and suburban growth together increase the likelihood that tornadoes will strike subdivisions and damage or destroy hundreds or thousands of homes.

8. Conclusion

Society has been tragically reminded that nature is a sometimes violent and unforgiving force. This year tornadoes have caused more than US$20 billion in damages and claimed 552 lives. While we can reduce casualties from more frequent weaker tornadoes, the options are much less attractive for people caught in the path of the numerous violent tornadoes which struck the U.S. in 2011. The same more or less applies to damages, as mitigation will not be economically attractive for the relatively rare violent tornadoes.

The 2011 tornado season resulted in the largest property loss of any tornado season on record and has raised concerns for insurers about tornadoes as possible catastrophic events. The challenge for public officials and for insurers is to find ways to model the return frequency of these events to allow for the necessary preparations and to ensure sufficient claim reserves. Normalised tornado damage, which provides a way to adjust past losses for changes in population and wealth, suggest that the 2011 season is not without precedent, but rather comparable to at least two prior years: 1953 and 1965. Thus we can reasonably expect to see a repeat of the insured losses from this year at some point in the future.

References

Brooks, H. E., and Doswell, C. A. III (2001) "Normalized damage from major tornadoes in the United States: 1890-1999", *Weather and Forecasting*, 16:168-176.

Downton, M. W., Miller, J. Z. B. and Pielke, Jr., R. A. (2005) "Reanalysis of the U.S. national flood loss database", *Natural Hazards Review,* 6: 13-22.

Gall, M., K. A. Borden, and Cutter, S. L. (2009) "When Do Losses Count? Six Fallacies of Natural Hazard Loss Data", *Bulletin American Meteorological Society,* 90: 799-809.

Grazulis, T.P. (1993) *Significant Tornadoes 1680-1991*, St. Johnsbury, Vt.: Environmental Films.

Merrell, D., Simmons, K. and Sutter, D. (2002) "The Market for Tornado Safety: Analysis of Applications to the Oklahoma Saferoom Initiative", *Journal of Economics*, 28(1): 35-50.

Pielke, R. A., and Landsea, C. W. (2005) "Normalized Hurricane Damages in the United States: 1925-1995", *Weather and Forecasting*, 13(3): 621-31.

Simmons, K. and Sutter, D. (2011) T*he Economic and Societal Impact of Tornadoes*, Chicago: AMS Books and University of Chicago Press.

Simmons, K. and Sutter, D. (2007) "Tornado Shelters and the Housing Market", *Construction Management and Economics*, 25(11): 1119-1126.

Simmons, K., Sutter, D. and Pielke, R.A. (2012) *Normalized Tornado Damage in the United States: 1950-2010*, working paper, forthcoming.

Smith, M. (2010) *Warnings: The True Story of How Science Tamed the Weather*, Austin, TX: Greenleaf Book Press.

Sutter, D., De Silva, D. and Kruse, J.B. (2009) "An Economic Analysis of Wind Resistant Construction", *Journal of Wind Engineering and Industrial Aerodynamics*, 97(3-4): 113-119.

Viscusi, W. K., and Aldy, J. E. (2003) "The value of a statistical life: A critical review of market estimates throughout the world", *Journal of Risk and Uncertainty*, 27(1): 5-76.

Wurman, J., C. Robinson, A.P. and Richardson, Y. (2007) "Low-level winds in tornadoes and potential catastrophic tornado impacts in urban areas", *Bulletin American Meteorological Society*, 88(1): 31-46.

9. 2011 Thai floods and insurance

Christophe Courbage, Meghan Orie and Walter R. Stahel

1. Introduction

In 2011, Thailand experienced its heaviest flooding in 50 years with devastating effects. The brunt of the economic loss is being borne not only by home owners and farmers, but mostly by manufacturers. Thousands of factories suspended production, subsequently disrupting supply chains with major local and global economic consequences.

The Thai floods came at the end of a year that has been rich in natural catastrophes. In the past, floods have periodically occurred in Thailand, but the difference from previous floods lies in the complexity caused by changed economic land use patterns. For example, in the case of paddy fields, floods act as a fertilizer and, at worst, may postpone the next harvest, whereas in the case of industrial estates, floods interrupt all business activity and often lead to environmental pollution (chemicals released, diesel oil tanks bursting, waste water installations being destroyed) the consequences of which may not become apparent for some time.

This complexity also has an impact on insurance. Due to a very low penetration rate of flood insurance for residential properties, the insured losses have occureed almost entirely in the manufacturing sector. Given the large losses manufacturers incurred, insurers have been impacted seriously by the floods. In reaction, primary insurers have started imposing flood coverage sublimits and increased premiums, and reinsurers have tightened underwriting.

Consequently, the Thai government decided to set up various measures in the aftermath of the floods. In order to increase insurance capacity, it has decided to implement a flood insurance pool involving the insurance industry. The Thai government has also undertaken natural catastrophe risk management measures such as flood mapping and water risk management.

Due to the topography of Thailand, it may take a considerable time before the flood water has completely run off and the full damages can be assessed. For these reasons, a clear picture of the Thai floods may not become available for some time. This chapter, then, offers a partial analysis of the event and quotes the estimates available at the time of printing.

This chapter begins by briefly introducing the nature of the floods. Then it addresses the economic losses and the consequences for the various economic sectors and discusses the risk factors that led to increased economic losses caused by the event as well as the risk mitigation factors. Finally, it looks at the impact of the floods on the insurance market and discusses the various solutions under discussion to make coverage for natural catastrophe affordable.

2. Background on the event

Thailand is located in Southeast Asia, bordering the Andaman Sea, the Gulf of Thailand, Myanmar, Laos, Malaysia and Cambodia. It covers roughly 513,000 km^2 and is slightly larger than Spain (Central Intelligence Agency, 2012). The Chao Phraya River is formed at the convergence of many small tributeries in the north and passes from north to south through what can be classified, based on economic, social and ecological criteria, as four geographic regions of Thailand (Disaster Resilience Leadership Academy, 2011): the northern region, the northeastern region, the central region and the southern region.

Each region has distinct geographical features. There are the Thai Highlands, the mountainous region in the north, the Khorat Plateau in the northeast, the Malay Peninsula in the south and a low-land central plain that is drained by the Chao Phraya River and its tributaries into the Bay of Bangkok. The Mekong River, which borders the Khorat Plateau, and the Chao Phraya River are the main sources of water for Thailand's agricultural industry.

Beginning in July 2011, the combination of the remnants of tropical depression Haima and tropical storm Nok-ten led to severe flooding in 65 of Thailand's 77 provinces, mostly in the Mekong and Chao Phraya basins (AFP, 2011). In total, the monsoon rains were 46 per cent higher than the year before.

Northern, north-eastern and central Thailand were most affected as the flood waters moved from north to south in a matter of months. The floods overwhelmed floodgates leading to inundation in large paddy fields in Singburi, Ang Thong and Ayuttaya (central region) by September (Bangkok Post, 2011a). They overwhelmed dams, which were forced to increase their rates of discharge, possibly worsening downstream flooding by the beginning of October (The Nation, 2011), and they breached barriers protecting industrial estates in Ayutthaya. This led to major manufacturing disruptions by the end of October. Despite all this destruction, central Bangkok was mostly spared, though not without political controversy.[1]

The physical extent of the floods can be illustrated by the fact that by September, a third of the Kingdom's total surface was under water. As a consequence, it can be expected that the contamination of the drinking water systems could lead to later health impairments of large parts of the Thai population.

3. The economic losses

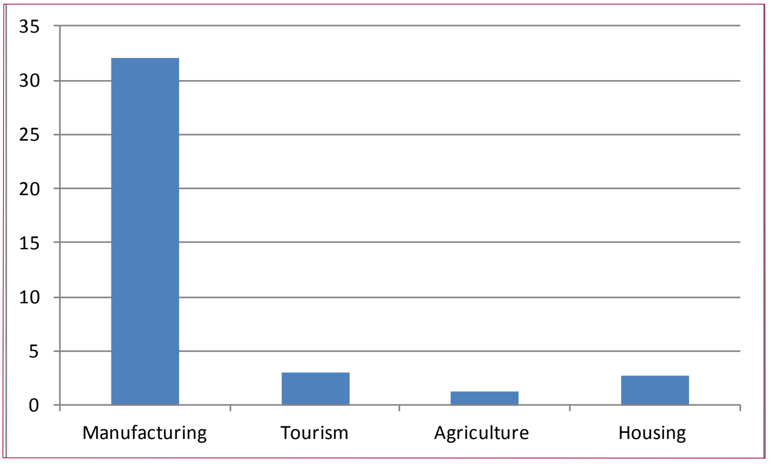
3.1. The direct cost of natural disasters

As of 1 December 2011, the total economic damages and losses of the Thai floods were estimated at THB1,425 billion (US$45.7 billion), according to a rapid needs assessment

1 According to The Asia Foundation (2011), "*Having exhausted all stop-gap measures to protect Bangkok, the authorities insisted that they had no other option left than to initiate a controlled release of the floodwaters through the Chao Phraya and the labyrinth of canals or klongs that flow through and around the capital. This decision led to greater flooding and destruction in the city's surrounding areas*".

conducted in early December 2011 by the World Bank and Global Facility for Disaster Reduction and Recovery (GFDRR) in collaboration with various development partners, the Thai Ministry of Finance and 40 other government agencies. The World Bank defines damages as "*the destruction of physical assets. Damages occur immediately and can be built back*... [whereas losses are defined as] "*foregone production/income. Losses occur over a longer period of time following a disaster and cannot be recovered. Together the damages and losses make up the total effect of the economic impact of a disaster*" (The World Bank, 2011b). Of the total losses, 90 per cent (about THB1,284 billion) are being borne by private owners. The public sector is bearing 6 per cent (THB81.4 billion) of the losses, not including losses suffered for flood prevention construction and humanitarian relief. In terms of magnitude by business sector, manufacturing suffered the most significant losses, followed by tourism, housing and agriculture as indicated on Figure 1.

Figure 1. Total losses and damages by sector in US$ billions



Source: The World Bank (2011).

Manufacturing losses of THB1,007 billion (approximately US$32 billion) occurred not only because of the damage done to factories but also because of the large scale of disruption in manufacturing operations caused by the flood (The World Bank, 2011b). According to the Labour Ministry more than 14,000 businesses have had to close nationwide due to flooding. The floods damaged seven major industrial estates in the central region, and 1300 factories were affected, halting production. These supply chain disruptions greatly increased the profits lost globally. Car manufacturers, electronics manufacturers and insurers have been the worst affected.

3.2. Supply chain disruptions

Affected industrial estates

Defences protecting industrial sites were breached particularly in the central region at various times throughout the flooding, leaving seven industrial estates (Bang Pa-in, Bangakdi, Factory Land, Hi-Tech, Nava Nakorn, Rojana and Saha Rattana Nakorn) in waters ranging from 1 to 3.4 meters. Hi-Tech, Bang Kadi and Nava Nakorn, one of Thailand's oldest and largest industrial estates with a large concentration of Japanese manufacturers, had to be evacuated. According to reports, the industrial estates of Lat Krabang, Bang Chan, Bang Phli and Bang Poo were at risk of being flooded as late as December 2011. In total, the Federation of Thai Industries (FTI) estimates that damage to the industrial sector could result in between THB300 billion to THB400 billion (US$9.8 billion and US$13.1 billion).

In October 2011 officials at Hi-Tech reported that it will take 10 weeks to drain away the 12 million cubic meters of water in their facility, while officials at the Nakorn plant said that it would take 13 weeks to clean the plant after the water has receded and about one year to fully re-build the infrastructure.

Car manufacturing

According to reports, 450 Japanese manufacturers have been affected by the floods. All nine Japanese car manufacturers with operations in Thailand have had to suspend production causing major losses in profit due to flood damage, like Honda, and/or component shortages, like Toyota and Nissan. The floods have been all the more devastating since several Japanese companies have moved operations into Thailand to avoid the strong yen and power shortages affecting Japan since the Tohoku earthquake. Consequently, the production impact was felt outside Thailand, forcing companies such as Toyota and Honda to cancel overtime and delay the launch of new products. For example, Toyota was forced to cancel overtime at all of its Japanese vehicle plants, reducing production by 7,000 vehicles in one week. The Thai floods also impacted factories in Indonesia, Vietnam and the Philippines. However Nissan has stated that it is able to prevent the impact on production by procuring substitute parts through its global supply chain which was strengthened after the Tohoku earthquake (Guy Carpenter, 2011).

Electronics

Like car manufacturers, electronics firms like Toshiba, Sony, Nikon and Nidec have suspended production at their Thai factories due to flood damage and/or supply shortages, leading to major annual losses. The impact on electronics companies has been severe. For example, Sony reduced its full-year operating profit outlook by 90 per cent on 2 November. It also reported an unexpected third quarter loss of US$345 million. Sony predicts a US$1.2 billion annual loss for the year 2011-12 (Guy Carpenter, 2011).

For these industries in the private sector, ignoring the lessons of risk management can multiply their economic vulnerability. The global manufacturing supply chain, for example, ignores that economy of scale always goes hand in hand with dis-economy of risk: the smaller the number of plants, the higher the risk of interruptions. And the bigger the distances between the members of the supply chain and the smaller the stocks, the higher the risk of interruptions of the supply chain. The 2011 Thai floods increased the awareness of many multinational companies to the vulnerabilities of supply chains that they have perfected for years to make them more efficient in order to lower costs. The floods in Thailand at the end of 2011 interrupted the supply chains of global manufacturing a second time, sometimes hitting the same companies. But business interruption at, or even the resulting bankruptcy of, suppliers may have no direct financial repercussions on the global manufacturers themselves. The increased awareness does then not lead to changes, primarily because increasing inventory even by a small amount to avoid supply shortages can cost large companies millions of dollars.

3.3. Other sectors' losses

Agriculture

The Agricultural Extension Department reported that 9.01 million rai (roughly 1.44 million hectares) of rice paddies[2] across the country have been flooded from mid-September to mid-November 2011 and that 7.21 million rai (about 1.15 million hectares) were in critical condition. According to the World Bank damages will be roughly THB40 billion (US$1.3 billion). The Office of Agricultural Economics (OAE) found that up to 1.4 million farmers were affected by the 2011 Thai floods. Of the total, 1.1 million are rice farmers and the rest deal with livestock, fishery and other crops. "*It might not be possible for many farmers to resume next year* [2012] *as their houses were also heavily damaged*," said an OAE official. According to the official, the floods will also affect the farm economy unless farmers have land that is well-irrigated or has sufficient water to grow a second crop rapidly (Bangkok Post, 2011b). Naturally these events have also affected the ways agricultural risks are covered and the market of crop insurance as it will be explained in a next section.

Tourism

Unlike the agricultural sector, those in the tourism sector have reason to be cautiously optimistic. It seems that flood damage will only minimally and briefly affect Thailand's tourism industry. Tourism accounts for six per cent of GDP and employs roughly 15 per cent of the workforce in Thailand (Reuters, 2011). The flooding is expected to have reduced the number of overseas tourists in 2011 from a target of 19.5 million to 18.5 million, causing a loss of THB95 billion (over US$3 billion) in revenue. Domestic tourism is expected to fall more drastically, by 90 per cent, according to the president of the Association of Domestic Travel (Reuters, 2011). That said, Thailand's tourism sector has historically had a tendency to recover quickly after major natural catastrophes because Thailand's tour operators have extensive experience of dealing with crises, because of the variety and geographic diversity of its tourist locations, and because the primary tourist infrastructure was relatively unscathed post-flood. Several analysts predict that the drop in tourist numbers will be brief since historically tourists have quickly returned to Thailand post-crisis due to its warm weather, reputation for hospitality, relatively low costs, and better travel infrastructure than its neighbours among other reasons (Reuters, 2011). In fact, according to the Pacific Asia Travel Association (PATA)'s data, though only available through the end of October 2011, international arrivals to Thailand continued to rise steadily through 2011, and are now roughly equal to 2010's numbers. This means that that when the November and December data is included, 2011's arrivals should surpass 2010's.

4. Risk factors

4.1. Risk reduction measures

Due to its tropical climate, many parts of Thailand are predisposed to seasonal flash-floods. Thus, the government must engage in disaster risk reduction activities in order to be prepared for such events. In 2007, the Disaster Prevention and Mitigation Act (DPM Act) was put into force. This act replaced the 1979 Civil Defence Act and the 1999 Fire

2 10.9 million hectares are planted with rice in total (CBC News, 2011).

Prevention and Suppression Act. Under the DPM Act, the National Disaster Prevention and Mitigation Committee (NDPMC) and the National Safety Council of Thailand (NSCT) are primarily responsible for policy-making on disaster risk management. Through a chain of command and reporting, the NDPMC collaborates with the Department of Disaster Prevention and Mitigation (DDPM), a department in the Ministry of Interior that coordinates disaster risk management activities by all related organisations at the national, regional, and local levels.

The NDPMC drew up the Strategic National Action Plan (SNAP) for Disaster Risk Reduction (Paksuchon, 2010) which was developed to fulfil the strategies outlined by the United Nations International Strategy for Disaster Reduction (UNISDR) in the Hyogo Framework for Action (HFA) to be enacted from 2010-2019. Structurally, the Thai government had also invested in drainage control systems, multiple dams, dykes, irrigation canals and flood detention basins that ultimately proved to be ineffective (Lebel *et al*., 2009).

According to many experts, the measures taken were ineffective because the government lacked disaster risk response, a response that results from political instability—including a powerful, politically engaged military—social polarisation and public mismanagement (Montlake, 2012), revealing problems in general and more specifically in disaster risk reduction governance (Thai Travel News, 2011). Among many complaints, the Thai Meteorological Department (TMD) claimed that it had warned the Royal Irrigation Department (RID) of abnormal weather for 2011, before the onset of a crisis. Though his department suggested that RID treated the flood accordingly, it seems the government took no heed. Other government officials claim that the government's storm tracking computer is not accurate enough; that it failed to organise parties responsible for flood protection; that the government failed to declare a state of emergency early enough for fear the military would use this opportunity to further consolidate power; and that many structures were the primary cause of flooding throughout the country, blocking natural channels of storm water evacuation. Also, the government failed to use heavy machinery to fortify and raise the height of the dykes protecting industrial complexes, instead it used sandbags which were overwhelmed by the flood waters (Guy Carpenter, 2011).

4.2. Risk increasing factors

Despite the government's lack of preparedness, the floods' impact may have been multiplied by the country's economic development: urbanisation due to population growth, large scale industrial agriculture and the construction of industrial estates. Thailand is the world's biggest exporter of rice and the biggest producer of rubber. Half of Thailand's primary forest areas have been replaced by rubber tree and palm oil plantations in the last 40 years. This type of agriculture retains precipitation to a much lesser degree than primary forests.

Not long ago, the location of the new industrial parks was paddy fields, ideal for the construction of large production buildings but prone to flooding. Such industry complexes and industrial agriculture are further at flood risk from land subsidence. Land subsidence is the gradual sinking or caving in of soil, caused by heavy groundwater pumping in areas that have flat low-lying topography and in the presence of a thick soft clay layer at the ground surface (Phien-wej *et al*., 2006). Groundwater pumping hit its peak in the 1980s; since then, the government has imposed a groundwater tariff, has implemented and enforced laws preventing groundwater pumping and has expanded public water systems to much success (The World Bank, 2012a). However, despite the government's efforts, it seems that years of groundwater pumping will result in some continued subsidence.

Industrialisation and development are resulting in migration to urban areas. Forty-three per cent of Asian populations are urban dwellers and the region is home to half of the world's largest cities. "*The stark reality is that disaster impacts in urban settings are felt much more intensely than in rural areas*," according to the 2020 strategy report of the Asian Disaster Preparedness Center. In the 1950s, only 10 per cent of the Thai population lived in towns, compared to a third today. Furthermore, Thailand's rapid urbanisation led to changes in the structure of the rain water run-off canals and the construction of settlements in flood plains.

In sum, the increase in losses is not only due to extreme weather events, but also to changes in socio-economic conditions. Population growth, continued urbanisation, and industrial development in exposed areas also mean increasing wealth, which will translate into higher economic losses in the future. And as in most natural disasters, economic losses are likely to hit the poor hardest. There is an urgent need for innovative insurance products to protect against natural catastrophes.

At the same time, unless governments effectively carry out the disaster risk reduction plans they have set out and incorporate them into development plans, economic losses will rise in the future. Measures of disaster risk and reduction thus gain increasing importance to mitigate the impact of future natural catastrophes.

5. The impact to the insurance industry

5.1. Insured losses and flood insurance

Flooding in Thailand set a new economic loss record, making it not only the country's most expensive catastrophe to date, but also the world's most expensive flood disaster. According to Standard and Poor's (2012), estimates for the Thai floods currently concur with an insurance market loss range of US$16 billion to US$18 billion. Of these losses it expects 10 to 15 per cent to be retained by the domestic market, 65 to 70 per cent by Japanese joint ventures or local subsidiaries and parent company branches in Thailand and up to 20 per cent by regional operations of international insurers. However, calculating the true cost of the floods could take years in terms of working out the lost business to Thailand. Indeed, there are a lot of difficulties and uncertainty in accurately estimating income lost to production shutdowns, and incurred costs due to supply chain disruptions and damage to property and equipment. In addition, loss adjusters only had limited access to sites beginning in mid-December.

Less than one per cent of households in Thailand have insurance coverage for flood. Mandatory household insurance only covers fire but the owner can buy additional protection for floods for only 0.02 per cent of the sum insured, according to the General Insurance Association (GIA). Due to this marginal penetration of flood insurance for residential properties, the insured losses came almost entirely from manufacturing and supply chains. Most commercial properties such as factories have industrial all-risk (IAR) policies with flood cover, with almost 100 per cent of the sum covered. Production or business interruption cover is separate from industrial all-risk policies. The majority of the multinational firms in Thailand either buy coverage from foreign insurers or self-insure through captive insurance operations. Japanese insurers write most of the commercial property/casualty business in Thailand. As the primary carriers make significant use of reinsurance, the net impact to the Japanese insurers on a risk basis is not expected to be significant unless the event limit is breached (A.M. Best, 2012).

Property insurance cover in Thailand is shrinking fast in the wake of the country's severe floods and reinsurers are pulling back on underwriting in Thailand. French state-backed insurer Caisse Centrale de Réassurance S.A. announced that it has ceased underwriting in Thailand, as well as in New Zealand and Australia, as a result of several natural disasters. In 2012, flood coverage will be separated from IAR policies (A.M. Best, 2012).

Some even predict that multinational reinsurers will more than double premiums for flood and all-risk policies while capping flood coverage. Primary insurers have started imposing flood coverage sub-limits, with some covering a mere 20 per cent of the amount insured, and rate hikes of up to 30 per cent as insurers now consider Thailand a high-catastrophe-risk country contrary to what it used to be.

5.2. Public-private catastrophe-risk fund

Due to concerns about the insurance industry's ability to absorb another hit in the future and to make affordable coverage for natural catastrophes, the Office of Insurance Commission (OIC) recently announced plans to set up a THB50 billion (US$1.6bn) catastrophe fund to provide insurance coverage for floods, windstorms and earthquakes. This risk-sharing scheme between the Thai government and the Thai non-life insurance sector will offer protection for households, small and medium enterprises and industrial factories. The fund will provide cover for the three main natural catastrophes to which Thailand is exposed: floods, windstorms and earthquakes. This catastrophe fund will act as a primary reinsurer and the fund will purchase a reinsurance programme to enhance capacity. According to the OIC, under the fund, catastrophe losses between THB30 billion and THB500 billion would be reinsured by foreign reinsurance companies. Insurance companies will be responsible for cover of losses up to THB2 billion. The government would take over through the catastrophe fund losses between THB2 billion and THB30 billion. The government-backed catastrophe fund will be run by an independent committee. The catastrophe fund may struggle to secure that level of reinsurance coverage in the current market at a reasonable cost as rates for Thai exposures have risen after the floods. This may lead the government to explore the use of alternative risk transfer and capital markets to provide this funding either through some sort of risk pooling or even instruments such as catastrophe bonds (Artemis, 2012).

Initially, the catastrophe fund would be sub-limited to THB100,000 per household; 20 per cent of the sum insured with a limit of THB5 million per small and medium enterprise; and 10 per cent of the sum insured with a limit of THB50 million per industrial company.

5.3. Crop insurance

Many farmers were impacted by the devastating 2011 floods and very few had crop insurance. Crop insurance has only recently become available in Thailand. It was offered locally in the 2009-2010 cultivation season, and was sold to farmers nationwide for the first time in 2011 (Bangkok Post, 2012). This insurance is jointly implemented by the the Bank for Agriculture and Agricultural Cooperatives (BAAC) and the General Insurance Association, and only covers seasonal rice crops in a limited capacity so far. Premiums are subsidised by the government and collected by the BAAC, which acts as an intermediary and forwards the premiums to private insurance companies. The plan charges a low premium of THB129.47 per rai, putting premium income at THB130 million but with a payout as high as THB400 million last year. With such low premium income, few insurers have joined the programme. Faced with this limited insurance capacity, the BAAC is proposing a crop insurance fund to provide higher risk cover from natural disasters. The fund is expected to start with at least THB5 billion (US$164 million) in its coffers, providing protection for valued crops like rice, maize and tapioca. The new fund could compensate farmers at full cost, such as THB5,000 a rai (1,600 m^2) for rice farmers, and more for orchard growers. A possibility, as proposed by the BAAC could be to merge the crop insurance scheme with the government catastrophe fund.

Another form of insurance for agricultural risk that has been available since 2010 in Thailand is weather index insurance. This insurance product is designed to provide insurance payments when weather variables (like temperature or rainfall) reach certain predetermined levels. Japanese property insurance firm Sompo Japan in cooperation with the Japan Bank for International Cooperation (JBIC), currently offers such insurance to rice farmers in Khon Kaen province in northeast Thailand, as part of its climate change adaptation initiative. The development of weather index insurance requires highly reliable long-term meteorological data. Khon Kaen Province has relatively precise meteorological weather stations, making it a suitable target for product development. So far, the product has been quite successful with 6,000 applications received for the first four month of 2011 (Sompo Japan, 2011).

6. Conclusion

The 2011 Thai floods have been dramatic both in terms of economic losses and fatalities. They have damaged millions of homes, business and manufacturing facilities. Thousands of businesses had to close nationwide, including car and electronic manufacturers. These supply chain disruptions greatly increased the profits lost globally. The agricultural sector also reported high losses especially in rice crop production. The tourism sector has also suffered damages and losses but to a lesser extent from the loss of tourism revenues that mainly took place during a six-month period.

Given the overall uncertainties still surrounding the events, it is too early to draw a definitive picture of their impact on the country as well as their effect on insurance. However, it seems clear that the 2011 floods will bring significant changes to the insurance industry in Thailand and to the coverage of natural catastrophe in this country. While Thailand was regarded to be at low risk of natural catastrophe a few years ago, the country is now considered to be a risky natural catastrophe area which makes flood more difficult or expensive to insure.

The insurance market for natural catastrophe is very small in Thailand in comparison to other countries, and it is clear that insurance capacity is now even more limited. Insurers have started to implement sub-limits, to tighten underwriting and price responsibility. Some reinsurers are pulling back on underwriting and a few have even decided to quit the Thai market.

These events have definitely changed the perception of risk in the country, and all stakeholders seem to be coming up with strategies to mitigate risk and improve natural catastrophe coverage. For instance, due to concerns about the ability of the insurance industry to absorb another hit in the future, the Thai government is considering a flood risk insurance pool involving the insurance industry. Other stakeholders are suggesting creating a crop insurance fund to provide higher coverage from natural disasters.

The government is also taking measures to mitigate the flood risks so as to effectively respond to the challenges flooding poses. In the aftermath of the floods, the authorities have begun to map out a national flood plan costing some US$13.6 billion over the next five years, to prevent a repeat disaster and secure investor confidence. The Thai government also recently approved a budget of THB5 billion (around US$162 million) to implement 117 new "flagship" water management and flood prevention projects. Around 240,000 hectares of land have been set aside as water catchment areas, which the Prime Minister said should store nearly 5 billion cubic meters of water.

These decisions will hopefully open the path to a global strategy to better manage natural catastrophe in Thailand. Only time will tell.

References

AFP (2011) "Thai floods death toll tops 800", available at *http://www.thaivisa.com/forum/topic/522783-thai-floods-death-toll-tops-800/*

A.M. Best (2012) "Flood Losses Prompt Key Changes in Thai Insurance Industry", Best's Briefing, 9 February.

Artemis (2012) "Thailand to establish catastrophe insurance fund", available at *http://www.artemis.bm/blog/2012/01/17/thailand-to-establish-catastrophe-insurance-fund/*

Asian Disaster Risk Reduction Center (2008) "Information on Disaster Risk Reduction of the Member Countries: Thailand", available at *http://www.adrc.asia/nationinformation.php?NationCode=764&Lang=en&NationNum=09*

Bangkok Post (2011a) "Bangkok 'safe' from river flooding", available at *http://www.bangkokpost.com/news/local/257670/bangkok-afe-from-river-flooding*

Bangkok Post (2011b) "Floods: Damage to farms & crops", available at *http://www.bangkokpost.com/learning/learning-from-news/266566/floods-damage-to-farms-crops*

Bangkok Post (2012c) "Farmers in the dark over crop insurance", available at *http://www.bangkokpost.com/news/investigation/277314/farmers-in-the-dark-over-crop-insurance*

Business Report Thailand (2011) "After the deluge", available at *http://www.businessreportthailand.com/bangkok-flooding-deluge-12787*

CBCNews (2011) "Thailand flood damage cost rises to billions", available at *http://www.cbc.ca/news/world/story/2011/10/11/thailand-flooding.html*

Central Intelligence Agency (2012) "The World Factbook: Thailand", available at *https://www.cia.gov/library/publications/the-world-factbook/geos/th.html*

Disaster Resilience Leadership Academy (2011) *Yale-Tulane ESF-8 Program Special Report: Thailand Floods, Tulane University Law School: New Orleans*, available at *http://www.drlatulane.org/groups/thailand-floods/reports/Yale-Tulane%20Special%20Report%20%20Thailand%203%20DEC%202011.pdf/view*

Guy Carpenter (2011) "Cat-I Bulletin: Thai Floods", 3 November, available at *http://www.guycarp.com/portalapp/publicsite/catdocument.pdf?instratreportid=2077*

Lebel L., Tan Sinh T., Garden P., Seng S., Anh Tuan L. and Van Truc D. (2009) "The Promise of Flood Protection: Dikes and Dams, Drains and Diversions"in F. Molle, T. Foran and M. Käkönen (eds.) *Contested Waterscapes in the Mekong Region: Hydropower, Livelihoods and Governance*, London: Routeledge pp. 283-300, available at *http://books.google.ch/books?hl=de&lr=&id=16W9WQUaquMC&oi=fnd&pg=PA283&dq=Bangkok+Floods&ots=djetpQBWTm&sig=Vp8rhevFhyw6YipaTXb5bcR8UQg#v=onepage&q=Bangkokper cent 20Floods&f=false*

Montlake S. (2012) "Thailand's Flood Relief Party Meets Tide Of Complaints", Forbes, available at *http://www.forbes.com/sites/simonmontlake/2012/02/09/thailands-flood-relief-party-meets-tide-of-complaints/*

Paksuchon A. (2010) "Thailand on Disaster Risk Management 2011", Department of Disaster Prevention and Mitigation, Ministry of Interior, available at *http://www.adrc.asia/aboutus/vrdata/countryreport/nam2011_cr.pdf*

Phien-wej N., Giao P.H., and Nutalaya P. (2006) "Land subsidence in Bangkok, Thailand", *Engineering Geology*, 82(1): 187-201, available at *http://www.sciencedirect.com/science/article/pii/S0013795205002693*

Reuters (2011) "Ever-resilient Thai tourism may bounce back after floods", available at *http://www.reuters.com/article/2011/11/18/us-thailand-floods-tourism-idUSTRE7AH0JY20111118*

Romm J. (2011) "Thailand Suffers Most Expensive Flood in History, Destroying More than 10 per cent of Rice Farms in World's Top Exporter", Climate Progress, available at *http://thinkprogress.org/romm/2011/10/14/344749/thailand-most-expensive-flood-in-history-damaging-10-of-rice-crop-top-exporter/*

Sompo-Japan (2011) "Sales area expansion of Weather Index Insurance", available at *http://www.sompo-japan.co.jp/english/news/download/20110222_2.pdf*

Standard and Poors (2012) *Thai Floods Dampen Asian Insurers' Earnings And Capitalization*.

Thai Travel News (2011) "Thailand Floods: Experts say government failed to prepare for floods", available at *http://www.thaitravelnews.net/politics/thailand-floods-experts-government-failed-prepare-floods/*

The Asia Foundation (2011) "Thailand Flooding: Persistent Uncertainty and a Long Road to Recovery", available at *http://asiafoundation.org/in-asia/2011/11/02/thailand-flooding-persistent-uncertainty-and-a-long-road-to-recovery/*

The Nation (2011) "Major Dams Over Capacity", available at *http://www.nationmultimedia.com/new/national/Major-dams-over-capacity-30166650.html*

The World Bank (2012a) *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century*, Washington D.C.: The World Bank, available at *http://publications.worldbank.org/index.php?main_page=product_info&cPath=0&products_id=24210&wbid=376de0c041cfc8b821fc64f39bd322a7*

The World Bank (2011b) "The World Bank Supports Thailand's Post-Floods Recovery Effort", available at *http://go.worldbank.org/TCFEHXJML0*

About the authors

Christophe Courbage, Ph.D. in Economics, is Research Director at The Geneva Association in charge of the Health and Ageing and Insurance Economics research programmes. He is also Editor in Chief of *The Geneva Papers on Risk and Insurance—Issues and Practice* and International Faculty of the Singapore College of Insurance.

Christophe has lectured at various universities such as the University of Lausanne, the University of Geneva and the University Saint-Joseph of Beirut. Christophe is the former Executive Secretary of the European Group of Risk and Insurance Economists (EGRIE) and is Board Member of the Asia-Pacific Risk and Insurance Association (APRIA) Board of Governors.

J. David Cummins is the Joseph E. Boettner Professor of Insurance, Risk Management, and Financial Institutions at Temple University. Dr. Cummins has published 100 refereed journal articles and 32 book chapters and has written or edited 16 books. He has received more than 20 prizes for his research. Among his recent books is the Handbook of International Insurance (Springer). Dr. Cummins also has served as consultant to numerous business and governmental organisations including the Federal Reserve Bank of New York. He is a past-president of the American Risk and Insurance Association and is currently an Associate Editor of eight refereed journals.

Michael J. Guinery was a Vacationer within the Actuarial Services Business Unit of Ernst & Young whilst this article was being produced. He is currently in his final year of studying a Bachelor of Mathematics and Finance at the University of Wollongong.

Peter Höppe joined Munich Re in 2004 after a scientific university career. He has a Diploma degree in meteorology and PhDs in physics and human biology. Currently he is heading the Munich Re division “Geo Risks Research/Corporate Climate Centre”.

His main areas of research have been environmental effects on health, assessment of environmental risks, trends of natural catastrophes and climate change effects.

Peter Höppe is member of many scientific societies and holds different advisory functions for national and international organisations. He is founder and Chairman of the Munich Climate Insurance Initiative and one of the initiators of the Desertec Industrial Initiative.

Petra Löw has an university degree in geophysical geography, geology and remote sensing. She joined Munich Re in 2001 and worked several years with the focus on accumulation control and retrocession.

Since 2005 she has been working as a consultant for the Munich Re NatCatSERVICE, one of the largest global databases on natural catastrophe losses. She is responsible for all kind of statistical analyses and the Munich Re Downlaodcenter.

She plays an active role in the European Environmental Agency working groups on natural catastrophe data.

Eva Q. Ma was a Vacationer within the Actuarial Services Business Unit of Ernst & Young's Advisory Division whilst this article was being produced. Prior to working with Ernst & Young she was a tutor and research assistant at the Faculty of Business and Economics at Macquarie University.

Peter J. McCarthy is an actuarial partner with Ernst & Young in Sydney and is also the chairman of the Institute of Actuaries of Australia General Insurance Practice Committee. Peter's past experience includes consulting to governments and insurers for over 17 years and as a senior executive for over nine years in three large general insurers in Australia in roles of chief actuary and head of underwriting.

Alberto Monti is Associate Professor of Comparative Law with tenure at the Institute for Advanced Study IUSS Pavia. He teaches Risk and Emergency Regulation at the UME Graduate School of IUSS Pavia and Comparative Law and Economics at Bocconi University in Milan.

Professor Monti is a member of the OECD High-Level Advisory Board on the Financial Management of Large-Scale Catastrophes and maintains ongoing collaborations with several international organisations, academic institutions and research centers worldwide.

Admitted to the Italian Bar and specialised in the field of insurance and reinsurance law, Professor Monti regularly acts as legal counsel and arbitrator for major international clients.

Robert Muir-Woods, MA Ph.D., Chief Research Officer, Risk Management Solutions.

After a first degree in Natural Sciences and a PhD in Earth Sciences from the University of Cambridge, where he was also a Research Fellow, since 1992 Robert has worked on the development of methodologies for catastrophe loss modelling of earthquake, tropical cyclone, windstorm and flood perils in Europe, Japan, North America, Caribbean and Australia. He has been head of research at RMS since 2003 with a mission to explore enhanced methodologies for natural catastrophe modelling and develop models for new areas of risk. He has been technical lead on a number of catastrophe risk securitizations, was Lead Author on Insurance, Finance and Climate Change for the 2007 4th IPCC Assessment Report and Lead Author for the 2011 IPCC *Special Report on Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation*. He is Vice-Chair of the OECD High Level Advisory Board of the International Network on Financial Management of Large Catastrophes and has worked with The Geneva Association in the development of their policies and actions around climate change and insurance. He has published six books, written scientific papers on earthquake, flood and windstorm perils and published more than 200 articles.

Masaaki Nagamura is Division Head of Corporate Social Responsibility at both Tokio Marine & Nichido Fire Insurance Co., Ltd., and its parent, Tokio Marine Holdings, Inc. He joined Tokio Marine & Fire Insurance in 1986, and has experienced the fields of commercial underwriting and U.S. branch operation, prior to serving Corporate Planning Department since 2004.

Meghan Orie holds an M.A. in Development Studies from The Graduate Institute of International and Development Studies, Geneva, and a B.A. from the University of Georgetown. She has been Research Assistant at The Geneva Association since April 2010 where she researches issues linked to risk management, especially climate risk and insurance, and liability.

Roger A. Pielke Jr. has been on the faculty of the University of Colorado since 2001 and is a Professor in the Environmental Studies Program and a Fellow of the Cooperative Institute for Research in Environmental Sciences (CIRES). Roger's research focuses on the intersection of science and technology and decision making. In 2006 Roger received the Eduard Brückner Prize in Munich, Germany for outstanding achievement in interdisciplinary climate research. Before joining the University of Colorado, from 1993-2001 Roger was a Scientist at the National Center for Atmospheric Research.

Rick Shaw advises the Actuaries Institute on public policy and government relations. Prior to that he was Chief Actuary of the Bermuda Monetary Authority, and has advised the World Bank and IMF on social security reform in the Middle East.

Kevin Simmons (Ph.D.) is known internationally for his work on the economics of natural hazards. His research has been highlighted and he has been interviewed by the New York Times, CBS Evening News, Fox Business, Christian Science Monitor and USA Today among others. He has published more than 50 articles and co-authored 2 books with Dan Sutter, Economic and Societal Impacts of Tornadoes and Deadly Season: Analyzing the 2011 Tornado Outbreaks. Currently, he is a Professor of Economics at Austin College where he holds the endowed Clara R. and Leo F. Corrigan Chair of Economics.

Walter R. Stahel has been Vice-Secretary General and Director of risk management research of The Geneva Association since 1986. He has been Visiting Professor at the Faculty of Engineering and Physical Sciences, University of Surrey, and Guest Lecturer at Tohoku University, Japan, on business models for sustainable development, since 2003.

Since 1986, he has been in charge of the Research Programme on Risk Management and responsible for the M.O.R.E. seminar series (Managing Risk in the Economy) and also in charge of editing and publishing the Risk Management Newsletter of The Geneva Association. In June 2008, the new Climate Risk and Insurance (CR+I) Project was started under Stahel's direction, who then initiated the new CR+I Seminars, which are held annually in the Southern hemisphere.

Daniel Sutter (Ph.D.) is currently Professor of Economics with the Manuel H. Johnson Center for Political Economy at Troy University and is a Ph.D. graduate of George Mason University. His research interests include the societal impacts of extreme weather, the value of weather forecasts, the value of and market for mitigation, the economics of the news media, the market for ideology, and constitutional economics. Dr. Sutter has published over 85 articles in scholarly journals in economics, atmospheric sciences, civil engineering, and political science. He has co-authored with Kevin Simmons two books on the societal impacts of tornadoes.

Publications of The Geneva Association

For a complete list of our publications and how to get them, consult our website at www.genevaassociation.org

Books and monographs

Insurance and Resolution in Light of the Systemic Risk Debate—A contribution to the financial stability discussion in insurance

Edited by Daniel Haefeli and Patrick M. Liedtke, February 2012.

Company failures are at the heart of the systemic risk discussions and are occupying the minds of many regulators, supervisors and policymakers the world over. Much of the discussion is centred around banking and the most recent experience during the financial crisis. Experts realise how much damage failures in banking often create and how quickly they can generate a systemic threat and consequently an immediate need for substantial and very expensive government interventions. The picture in insurance is much less clear to many of those experts. And while historically no insurance failure ever created a systemic financial crisis, the issue of recovery and resolution in insurance demands special attention and careful analysis: How do these processes work specifically in insurance and how do they relate to the systemic risk discussions and possible new financial services regulation?

Building on the first three reports of The Geneva Association on financial stability, this report examines the existing features of recovery and resolution mechanisms in insurance and their relation to ongoing international supervisory and regulatory discussions on systemic risks. It also proposes recommendations for possible measures to increase the existing resilience of financial systems.

Financing Long-Term Care in Europe—Institutions, Markets and Models

Edited by Joan Costa-Font and Christophe Courbage, Palgrave Macmillan, 2012.

The ageing of the European population brings new financial risks that call for state, market and societal responses. In 2011, the first baby-boom generation is turning 65, and forecasts predict that the size of the old-age population in need of long-term care will double in the next 50 years in Europe. However, how different countries are responding to the challenge of financing long-term care is still a question open to further examination, including the role of market development, changing intergenerational contracts and especially the constraints of state intervention.

Growing long-term care needs in several European countries as well as the reshaping of traditional modes of care-giving further increase the pressure for sustainable funding of more comprehensive long-term care systems. This book examines different forms of partnership and the potential cooperation of state, market and societal stakeholders. It not only offers a full understanding of the institutional responses and mechanisms in place for financing old age but also provides a deep analysis of both the demand and supply factors underpinning the development of financial instruments to cover long-term care needs in Europe.

The Future of Insurance Regulation and Supervision—A Global Perspective

Edited by Patrick M. Liedtke and Jan Monkiewicz, Palgrave Macmillan, April 2011.

The recent financial crisis has provoked a broad spectrum of regulatory observations and possible responses. Currently most of these proposals have been quick solutions to politically pressing questions and often only address parts of regulatory systems, but not the whole. At times, the result has been more confusion than clarity. Although historically wide-ranging reshaping has been a common phenomenon after the severe failure of an existing financial infrastructure, there is an important difference this time—the global reach of today's markets

and enterprises. Moreover, never before have so many reforms following a banking crisis not only affected the banking sector but also other parts of the financial services sector, such as insurance, the social systems and,of course, our real economy.
Written by leading academics, researchers and insurance industry experts, this book offers a diversified perspective on how the regulatory and supervisory framework for the insurance sector will develop over the coming years. It is supported by The Geneva Association, the world-leading think tank of the private insurance industry.

Considerations for Identifying Systemically Important Financial Institutions in Insurance

Edited by Daniel Haefeli and Patrick M. Liedtke, The Geneva Association, Geneva, April 2011

The Geneva Association's efforts in the field of financial sability in insurance continue with this report which addresses two fundamental areas that are currently occupying policy-makers' and regulators' agenda: in Part I "A Methodology to Identify Systemically Important Financial Institutions (SIFIs) in Insurance", and in Part II "An Analysis of the AIG Collapse: understanding systemic risk and its relation to insurance".

The methodology presented in Part I is a logical further development of the earlier work carried out by The Geneva Association. It is inspired by the need to develop a comprehensive approach to identifying potentially systemically risky activities and the entities that carry them out.

Part II provides an analysis of the AIG case, which regularly features prominently in discussions about systemic risk and insurance and which is often misunderstood. The analysis aims to provide more clarity on this oft cited example and sets it in the wider context of systemic risk issues and their relationship to insurance.

Key Financial Stability Issues in Insurance—An account of The Geneva Association's ongoing dialogue on systemic risk with regulators and policy-makers, Follow-up report on Systemic Risk in Insurance

Edited by Patrick M. Liedtke and Kai-Uwe Schanz, The Geneva Association, Geneva, July 2010.

This report is based on a series of background papers and special presentations on systemic risk in insurance created between March and June 2010. It summarises the insurance industry's thinking—as advanced and crystallised by The Geneva Association—on these areas which include both corporate activities (e.g. asset management) and regulatory measures (e.g. crisis resolution mechanisms).

The Geneva Reports—Risk and Insurance Research

No.4: September 11—Ten Years On: lasting impact on the world of risk and insurance

Edited by Patrick M. Liedtke and Kai-Uwe Schanz, September 2011

Ten years after the terrorist attacks of September 11, 2001 The Geneva Association has initiated a comprehensive research effort focusing on the lasting impact of an event which was the most expensive man-made disaster for insurance ever and which in its immediate aftermath was widely viewed as heralding a new era in global politics, economics and business. This effort builds on The Geneva Association's seminal special monograph which, written and published in 2002, has proven remarkably prescient in many respects.

With the following collection of eight essays from leading industry economists, underwriting specialists and Geneva Association researchers, we intend to make a meaningful contribution to establishing the event's permanent relevance for the world of risk and insurance. We also hope to stimulate our readers to consider the long-term development of the insurance industry and the various ways in which it is intertwined with human lives and activities.

No.3: ***Anatomy of the credit crisis—An insurance reader from The Geneva Association***
Edited by Patrick M. Liedtke, January 2010

In this special Geneva Report, The Geneva Association has assembled a series of key articles written during and on the subject of the credit crisis, compiling them into an insurance "Reader". This Reader provides an insight into the credit crisis from an insurance point of view, looks at its impact on the insurance industry and finally examines the episode for lessons-learned and concerns that remain. The majority of the articles were written during the crisis and have been published unchanged in order to give a true insight into how thinking developed as the crisis unfolded.

With articles unchanged from the time of writing accompanied by a highly detailed timeline, the Geneva Report No 3 provides a very real anatomy of the credit crisis, the lessons learned from it and the implications it has for the insurance industry in future.

No. 2: ***The insurance industry and climate change—Contribution to the global debate***,
The Geneva Association, July 2009

No.1: ***Regulation and intervention in the insurance industry—fundamental issues***
E. Baltensperger, P. Buomberger, A.A. Iuppa, B. Keller and A. Wicki, February 2008

Newsletters (also available as e-newsletters)

- ***Insurance and Finance*** deals with research activities in the fields of finance where they are relevant to the insurance and risk management sector.
- ***Progres*** contributes to the exchange of information on studies and initiatives aimed at better understanding the challenges in the fields of insurance regulation, supervision as well as other legal aspects.
- ***Risk Management*** summarises The Geneva Association's initiatives in the field of risk management and is open to contributions from any institution or company wishing to exchange information.
- ***Insurance Economics*** which serves as an information and liaison bulletin to promote contacts between economists at universities and in insurance and financial services companies with an interest in risk and insurance economics.
- ***Four Pillars*** provides information on research and publications in the field of social security, insurance, savings and employment.
- ***Health and Ageing*** brings together facts and figures linked to health issues for people aged 50-80 and productive ageing, to try to find solutions for the future financing of health.
- ***World Fire Statistics.***
- ***General Information.***

Other publications of The Geneva Association

Journals

(published by Palgrave Macmillan for The Geneva Association)

- ***The Geneva Papers on Risk and Insurance—Issues and Practice***
  This prestigious journal, published quarterly, leads its field, publishing papers which both improve the scientific knowledge of the insurance industry and stimulate constructive dialogue between the industry and its economic and social partners.

- ***The Geneva Risk and Insurance Review*** is an international journal published in annual volumes of two issues. Its purpose is to support and encourage research in the economics of risk, uncertainty, insurance and related institutions by providing a forum for the scholarly exchange of findings and opinions.

Working Papers "Etudes et Dossiers"

These working documents present intermediary or final results of conference proceedings, special reports and research done by The Geneva Association and its partners. Among the last issues:

- *8th Insurance and Finance Seminar of The Geneva Association*, No. 384, January 2012
- *8th International Liability Regimes Conference of The Geneva Association,* No. 383, February 2012
- *8th Geneva Association Health and Ageing Conference—Insurance and Dementia*, No. 382, November 2011
- *3rd Climate Risk and Insurance (CR+I) Seminar*, No. 381, November 2011
- *38th Seminar of the European Group of Risk and Insurance Economists*, No. 380, October 2011
- *M.O.R.E. 25 Seminar*, No. 379, September 2011
- *16th International Conference on Space Activities Development—Risk Management & Insurance Aspects*, No. 378, September 2011
- *13th Meeting of ACCE & 7.5th International Liability Regimes Conference*, No. 377, August 2011
- *9th ART OF CROS*, No. 376, August 2011
- *27th PROGRES International Seminar*, No. 375, July 2011
- *11th CEO Insurance Summit in Asia*, No. 374, July 2011
- *14th Joint Seminar of the European Association of Law and Economics and The Geneva Association "Law and Economics of Natural Hazards Management in a Changing Climate"*, No. 373, June 2011
- *1st Climate Change Summit for Asia's Insurance Industry*, No. 372, May 2011
- *7th Insurance and Finance Seminar of The Geneva Association and Presentations on The Geneva Association's Financial Stability in Insurance Initiative*, No. 371, April 2011
- *6th Chief Risk Officer Assembly, A vision for risk management in the "new normal"*, No. 370, March 2011
- *World Risk and Insurance Economics Congress,* No. 369, March 2011
- *7th Geneva Association Health & Ageing Conference, U.S. and French Long-Term Care Insurance Markets Development,* No. 368, January 2011
- *7th International Liability Regimes Conference of The Geneva Association and 12th Meeting on The Geneva Association's Amsterdam Circle of Chief Economists, No. 367, January 2011*

www.genevaassociation.org

The Geneva Reports

Risk and Insurance Research

No. 5 • March 2012

2011 has been the most expensive year in recorded history both for the national economies and the insurance sector, with an estimated direct economic cost of US$380bn and original insured losses of approximately US$105bn.

It also showed an increasing severity arising from natural catastrophes, with a series of extreme events including the 11 March Japanese earthquake, the Australian and Thai floods, the New Zealand earthquakes, and the U.S. tornadoes.

These extreme events entail huge consequences in terms of human and economic losses but they also have important repercussions for the insurance industry.

This report presents the insurance' s role in managing extreme events and the mechanisms that make these insurable, both by the public and private sectors. In this context, it provides a detailed picture of the main extreme events that occurred in 2011 and analyses their impact on local insurance markets as well as the lessons learnt to efficiently manage these risks.

ISSN 1662-3738