Swiss Re

Lessons from recent major earthquakes

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Executive summary

Recent major earthquakes have caused large-scale damage to lives and properties.

Over the past two years, a number of large earthquakes have caused widespread property damage and resulted in a great number of fatalities and injuries. Fortunately, many of the businesses and households affected had insurance. The record-breaking economic losses from these events reflected the increased value and volume of construction in earthquake-prone zones. Insurance claims were also augmented by increased insurance penetration.

Insurance will pay for a large part of the damage caused by the recent earthquakes.

Among all the natural disasters, earthquakes are potentially the most destructive in terms of both loss of life and property damage. Earthquake insurance claims are also the most lengthy to assess, given their low-frequency and high impact. Although the total cost of the earthquakes in Chile, New Zealand, and Japan is not yet fully known, the insurance industry is playing a key role in post-disaster financing. While insurance cannot replace lost lives and livelihoods, appropriate insurance and other risk transfer mechanisms can greatly accelerate the recovery process.

Insurance consumers and risk managers are eager to understand what actions they can take to better mitigate earthquake risks.

The magnitude and impact of these recent events has raised earthquake risk awareness. Insurance buyers and risk managers are keen to learn how to better mitigate earthquake risk, especially in countries where seismic hazards are high. Efficient risk preparedness can dramatically reduce social vulnerability, while pre-disaster financing mechanisms, such as insurance, can greatly lower government financial exposure, thus accelerating the reconstruction phase.

Earthquake insurance coverage is still low.

Earthquake insurance coverage is still quite low, even in some industrialised countries, resulting in post-disaster loss financing and increased dependency on government intervention. In the absence of widespread insurance coverage, economic losses of great magnitude can only be addressed with significant public sector funding by relief organisations or governments, and ultimately must be borne by taxpayers.

Public awareness of earthquake risk remains low.

The low frequency of major earthquakes tends to create the perception that earthquake risk is low. In turn, the take-up rates for earthquake insurance remain subdued. However, the disastrous events of the last two years are a stark reminder that large parts of the globe are heavily exposed to earthquake risk. Raising public awareness of earthquake risk is sorely needed. Solutions also need to be discussed for how governments, businesses, and households can help mitigate the losses caused by major earthquakes.

Underwriters can also learn from the recent earthquakes, especially from the effects of secondary loss agents.

With respect to underwriting, there are also key lessons to be learned from the recent earthquakes. In the affected markets, underwriters have risk models available to them for assessing earthquake risk in insurance portfolios. The models are able to quite accurately predict the damage caused by ground shaking. However, the events in Chile, New Zealand and Japan dramatically highlighted the importance of secondary loss agents (ie losses that do not directly result from the ground shaking), such as tsunami-induced damage, liquefaction[1], and business interruption. Although losses due to secondary agents contributed significantly to overall insurance claims, they are not yet sufficiently considered in commercially available earthquake risk models.

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[1] Liquefaction is a phenomenon whereby soil loses strength in response to earthquake shaking, causing it to behave like a liquid.

Introduction

A series of deadly and costly earthquakes

The Tohoku earthquake was the most powerful known earthquake ever to have hit Japan.

On 11 March 2011, an earthquake with a magnitude of 9.0 thrust against Northern Japan's from its offshore epicentre near Tohoku, triggering a powerful tsunami that eventually reached the entire Pacific Rim. The earthquake was the most powerful known to have ever hit Japan and the fourth-strongest worldwide since 1900. Together with the ensuing tsunami, the earthquake caused the loss of more than 19 000 lives. It also brought widespread destruction to infrastructure and property, including nuclear facilities. Furthermore, logistic and supply chain interruptions, as well as electrical shortages due to do the shutdown of nuclear power plants, all had severe economic repercussions.

There has been a series of deadly and costly earthquakes in the last two years.

The Japanese earthquake, though the biggest, was just one of a series of devastating and costly earthquakes in the last two years. The first hit Haiti in January 2010, leading to the tragic loss of over 220 000 lives. Just after that, in February 2010, a magnitude 8.8 earthquake hit Concepción in Chile, causing the loss of 562 lives. Later, in September 2010 and again in February 2011, New Zealand was hit by earthquakes in which 181 people lost their lives. A few months after the Japan earthquake, a magnitude 7.2 earthquake struck Eastern Turkey in October 2011. The scale of the devastation from this last event has yet to be assessed, but the earthquake was the largest to have hit Turkey since 1999.

The economic losses from the 2011 earthquakes were the highest ever recorded ...

The cumulative catastrophic impact of the earthquakes on society is overwhelming. At more than USD 226bn, earthquake economic losses in 2011 are the highest ever recorded worldwide. In 2010, the economic losses caused by earthquakes also stood well above the average, though at approximately USD 50bn they were far below those in 2011.

... resulting in record-high earthquake insurance claims.

The insurance industry was, as a result, heavily impacted. According to current estimates, earthquake-insured claims for 2011 have broken the world record, and now surpass USD 47bn. Earthquake-insured claims from 2010 are the third highest on *sigma* records, the second being 1994, when the Northbridge earthquake struck California and cost the industry over USD 21bn (at 2011 prices).

The insurance industry's contribution to reconstruction varies greatly in different countries.

However, the share of the insurance industry's contribution to the reconstruction effort differs greatly for the various events, as Table 1 shows.

Table 1
Recent major earthquake events, USD billion (at 2011 prices)

			Economic losses	Economic losses as % of GDP	Insured losses	Insurance industry contribution[2]
	11.03.2011	Japan	up to 300	up to 5.4%	35	up to 17%
	27.02.2010	Chile	30	18.6%	8	27%
	22.02.2011	NZ	15	10%	12	80%
	12.01.2010	Haiti	8	121%	0.1	1%
	04.09.2010	NZ	6	5.3%	5	81%
	06.04.2009	Italy	4	0.2%	0.5	14%
	23.10.2011	Turkey	0.75	0.10%	0.03	4%
*	04.04.2010	Mexico	0.95	0.09%	0.2	21%

* Excluding minor losses for US
Source: Swiss Re *sigma* catastrophe database

[2] The insurance industry's contribution is measured as insured divided by economic losses.

The Tohoku earthquake caused record economic losses.

With an estimated economic impact of USD 210bn to 300bn[3], most of the financial losses came from the earthquake in Japan, making it the most costly natural catastrophe of all time. According to preliminary estimates, the earthquake generated USD 35bn in insured losses. These are the highest losses ever recorded for an earthquake, even surpassing the Northbridge earthquake in California in 1994. However, although substantial, the insured losses represent only a limited share (between 12% and 17%) of the total cost of the event.

The ratio of insured losses to economic losses varies greatly.

In contrast to Japan, in the case of the New Zealand, Chile, and Mexico/US earthquakes, a much greater percentage of the damage caused by the events was insured, and therefore borne by the insurance industry, leading to a ratio of 27% to 81%. The Haiti event, instead, led to very small insured claim amounts, with only a 1% ratio.

A country's capacity to withstand the devastation of a large earthquake depends on the size of its economy.

However, the capacity of a country to withstand large earthquakes depends on the size of its economy. In the case of Japan, the total damage represents only a fraction of its GDP[4], while for Haiti the large-scale devastation was considerably higher than its domestic GDP, severely impacting the livelihood of an already underserved population.

The last forty years of *sigma* records provide similar patterns of regional diversity.

Forty years of *sigma* records show similar patterns for the ratio of insured to economic losses. The ratio of insured to economic losses is a measure of the insurance industry's contribution to a country's reconstruction efforts. The higher the ratio is, the greater the insurance penetration and thus the higher the insurance contribution. Table 2 summarizes earthquake claims, or insurance industry contributions to reconstruction, in *sigma* records since 1970 for several earthquake prone countries.

Table 2
Earthquake claims and insurance contributions to recovery for selected countries (1970–2011)

	Number of events	Insured losses (USbn)*	Economic losses (USbn)*	Insured losses/ Economic losses
New Zealand	3	17	22	80%
US	13	25	64	38%
Chile	5	9	34	26%
Mexico	11	1	11	10%
Japan	24	40	373 to 463	9% to 11%
Turkey	26	2	30	5%
Italy	8	1	50	2%

* Insured and economic losses are indicated in USDbn at 2011 prices
Source: Swiss Re *sigma* catastrophe database

Insurance participation in reconstruction costs is highest in New Zealand, and lowest in Japan, Turkey, and Italy.

New Zealand presents the highest ratio of insured to economic losses. In New Zealand, residential earthquake insurance is mandatory and is administered through the Earthquake Commission, so the insurance industry has a much greater role to play in reconstruction efforts. Italy ranks last and so consistently, uninsured losses caused by earthquakes have had to be borne by the affected individuals or corporations, and by governments and municipalities as insurers of last resort. Japan also falls in the lower end of the scale.

[3] Currently the estimates for the financial losses of the Tohoku earthquake event are still very preliminary and should be taken cautiously,
[4] Around 5%, see Table 1.

Economic enlightenment from the earthquakes

Earthquake insurance penetration

Earthquake insurance penetration varies widely in countries with high seismic risk.

In Table 3, insurance penetration[5] is compared for selected countries with high seismic risk. Many factors weigh on penetration. For example, penetration depends on earthquake hazard, risk perception, state involvement and type of coverage (high versus low deductibles). The structure of the economy also has an impact. Physical-investment intensive economies tend to have higher insurance coverage, as opposed to service-based economies which have less physical assets to protect. Therefore, the numbers in the table are not fully comparable. However, they provide an indication of the role insurance would play in financing re-construction after an earthquake.

Table 3
Insurance penetration, premiums as % of GDP

	Non-life	Property	Commercial property	Residential property	Commercial earthquake	Residential Earthquake
Chile	1.61%	0.51%	0.46%	0.05%	0.25%	0.03%
NZ	5.09%	0.83%	0.35%	0.48%	0.09%	0.07%
California	2.89%	0.80%	0.44%	0.36%	0.03%	0.05%
Mexico	0.99%	0.18%	0.16%	0.02%	0.08%	0.01%
Japan	2.11%	0.26%	0.06%	0.20%	0.01%	0.03%
Turkey	1.06%	0.21%	0.14%	0.07%	0.01%	0.03%
Italy	2.32%	0.36%	0.18%	0.18%	<0.03%	<0.01%

Note: Figures are from 2009 and 2010.
Source: Swiss Re Economic Research & Consulting estimates

Earthquake insurance penetration is still low in some industrialised countries with high seismic risk.

Earthquake insurance penetration for commercial property is highest in Chile and New Zealand, and is considerably lower in countries like Japan, Turkey, and Italy. Residential property earthquake insurance penetration is highest in New Zealand and in California.

Chile's favourable regulatory environment has boosted earthquake insurance participation.

In Chile, the third largest property insurance market in Latin America, a favourable regulatory environment has helped boost participation by international insurers. Private insurance is now a key component of earthquake risk management, particularly for commercial property protection.

New Zealand has the highest residential earthquake insurance penetration.

In New Zealand, a mandatory government program is applied to every residential fire insurance policy written by private insurance companies. This combination of private and public insurance makes a substantial contribution towards financing losses due to major catastrophes[6]. Due to premium rate increases applied by the Earthquake Commission in response to the events in Christchurch, residential property insurance penetration is expected to increase from 2012.

California's earthquake insurance penetration is considered insufficient.

In the United States, California has the highest earthquake loss potential. Although it ranks highly, California's current level of earthquake insurance penetration is deemed insufficient for a region with such high seismic risk, high accumulation of valuable property, and high economic activity.

[5] Insurance penetrations is measured in terms of insurance premiums as a percentage of GDP.
[6] A natural disaster insurance cover (EQCover) is added automatically to each home or content fire insurance policy. The premium paid to the private insurance company includes the premium for EQCover. The private insurance company then transfers the EQCover premium to the Earthquake Commission.

Earthquake insurance penetration in Japan is low considering its high seismic activity.

At the junction of the Eurasian, Pacific, and Philippine Sea plates, Japan lies in one of the most seismically active areas of the world. Following the Tohoku earthquake, the property damage to commercial facilities and disruption to logistics and supply chains were so great that the full impact has yet to be fully assessed. Yet notoriously earthquake-prone Japan has one of the lowest levels of earthquake insurance penetration worldwide, particularly for commercial properties. Due to its low insurance penetration, the majority of catastrophic losses are borne by either corporations and individuals themselves, or the government (and hence eventually tax-payers).

Mexico is a pioneer in public-private insurance solutions for disaster risk protection.

In Mexico, another country with significant earthquake risk, residential insurance penetration is also quite low. However, in 2006 the government put in place its first reserve fund system for earthquakes of certain predefined magnitudes in specific regions. This innovative, public-private funding solution ensures that adequate funds are in place for emergency relief activities in the aftermath of a disaster, allowing the government more financial flexibility for the reconstruction process.[7]

Although penetration is still not at country target levels, earthquake insurance is steadily increasing in Turkey since the government made it mandatory and enhanced risk awareness measures.

Transcontinental Turkey sits at the crossroads of the Eurasian, Arabian, and African plates. Following two major earthquakes in 1999, the government made earthquake insurance coverage mandatory for residential buildings that fall within municipal boundaries. The Turkish Catastrophe Insurance Pool (TCIP) was founded in 2000 and today extends earthquake cover to close to four million policyholders already. Many more are expected to join their ranks in the coming years as awareness grows and enforcement tightens. What is certain now is that TCIP has succeeded in raising the profile and effectiveness of earthquake insurance among the Turkish public.

In Italy, the popular perception is that the government will provide relief and reconstruction in case of an earthquake. Private insurance penetration is low.

In Italy, a country with multiple seismic sources, residential earthquake insurance penetration is nevertheless negligible. The popular perception and inflated expectation is that in the event of a disaster, the government will provide full relief efforts including building restoration. Up until now, private individuals have had limited incentive to purchase insurance coverage. It remains to be seen whether the decade-long debate between the insurance industry and the government to make earthquake insurance mandatory will produce a legislative act.

[7] The 2006 catastrophe bond issued by the Mexican fund for natural disasters, FONDEN, was the first to cover disaster risk in the LAC (Latin America and the Caribbean) region. FONDEN issued a USD 160m catastrophe bond (CatMex) to transfer Mexico's earthquake risk to the international capital markets. In 2009, the Mexican government issued a further, USD 290m multi-peril catastrophe bond, providing coverage for earthquakes and hurricanes in specific regions.

Low earthquake risk perception

In the past two years, significant progress has been achieved in earthquake risk mitigation.

The way that recent earthquake disasters have been managed highlights that considerable progress has been made to mitigate physical risks. Even in disastrous earthquakes like the ones in New Zealand, Chile, and Japan, there were relatively few victims considering the magnitude of the events. The low loss of lives demonstrates achievements in earthquake damage prevention and risk preparedness. Stringent building codes require new buildings to be more earthquake resistant, thus lowering expected property losses. Governments have invested in making infrastructure more resilient and increased the focus on emergency response measures, thereby lowering the magnitude of damage and number of victims. Similarly, public awareness campaigns have helped entire populations ready themselves for disaster, both minimising risk and saving lives.

Loss control measures can reduce loss severity, but financial losses can still be catastrophic.

Risk and loss control measures can lower the severity of losses, but even the best preventative measures and emergency responses cannot fully protect home and business owners, especially from financial losses. Massively destructive earthquakes can cause prolonged interruption to economic activity, impacting the livelihood of survivors and business earnings.

Insurance can help mitigate the financial aftermath of an earthquake. It can also lower the overall cost of protection by encouraging risk prevention measures.

One way to lessen the financial blow following earthquakes is to use pre-disaster funding mechanisms such as insurance. Earthquake insurance can provide the funding needed for post-disaster reconstruction and timely recovery. As a solution, insurance can go beyond national capacity by spreading the risk not only among policyholders across geographic boundaries, but also across international re/insurers. Furthermore, by charging risk-based premiums, insurance encourages pre-disaster, risk-mitigating behaviour. For example, by linking premiums to the presence of stringent building codes, insurance can help lower the overall cost of protection.

When insurance take-up rates against major earthquakes are too low, taxpayers ultimately have to shoulder the burden.

However, earthquake insurance coverage is still quite low, even in some industrialised countries with high seismic risk. So in many cases, state budgets are the main source of post-disaster loss financing. However, economic losses of the magnitude from the earthquakes of the past two years cannot be shouldered by governments alone. In the absence of widespread insurance coverage, significant funding from relief organisations is needed. When relief funds prove insufficient, post-disaster public sector reparations must be pulled from last-resort government funds, and ultimately borne by taxpayers.

Because of the low frequency of earthquakes compared to other natural catastrophes, earthquake risk perception is low, even in places of deadly and destructive seismic occurrences.

Low insurance penetration attests to a population's low perception of risk. Large earthquakes occur rarely, so the ensuing human and economic losses tend to be forgotten relatively quickly, even in places in which there have been very deadly and damaging occurrences, like California. The low frequency of earthquakes, compared to other natural catastrophes, tends to shape the perception that earthquake risk is much lower than it actually is, resulting in too little insurance protection taken up by individuals, business owners, and public entities.

Insurance reduced the economic impact that two major earthquakes had on New Zealand.

One notable exception is New Zealand. Since its founding, the country has experienced relatively few damaging earthquakes. However, the region is geologically active and the country's seismic hazard is high. Despite the country's short favourable seismic history, the population has high earthquake risk awareness. In part this awareness is thanks to public earthquake education.[8] The government has also succeeded in making residential earthquake insurance mandatory. Therefore, when in 2010 and 2011 two very damaging earthquakes hit New Zealand in less than six months, the reminder of the country's high seismic risk came as less of a hit than it could have. Earthquake insurance efficiently absorbed a great deal of the losses caused by the events.

[8] The New Zealand Earthquake Commission (EQC) provides public education about seismic hazards. It sponsors exhibitions and is responsible for social marketing campaigns on earthquake risks.

Governments can go a long way to help promote insurance protection for large parts of the globe that are heavily exposed to earthquake risk.

Especially given the exceptional concentration of earthquakes of great magnitude in the last two years, governments have an important role in raising awareness that large parts of the globe are heavily exposed to earthquake risk. Furthermore, rising population density and high accumulation of property value makes the potential impact of an earthquake greater than ever. Governments can also increase take-up rates for residential and commercial property insurance by making such coverage mandatory, especially in high-risk areas. This, together with the already existing preventative measures, would lower the premium rates to more affordable levels and make protection accessible to larger segments of the population. A competitive and affordable insurance market, one which nevertheless reflects real earthquake risk, can greatly contribute to lowering a population's economic vulnerability to earthquakes.

Earthquake insurance product structuring is perceived as too complex.

The insurance industry could also take measures to simplify its product structures, especially if it wants to reach a larger number of people. For example, earthquake insurance coverage is often available as an extension of standard fire policies or through separate policies. Normally a number of exclusions apply, as well as a wide range of deductibles and loss limits, depending on the risk acceptance of the policyholder and the supply from local property insurers. While such product structuring allows better risk-based underwriting, it is nevertheless considered too complex by consumers. Often, this complexity, or perceived complexity, acts as a deterrent to the broader spread of much needed earthquake insurance.

Higher risk awareness and simple products would increase earthquake protection.

With improved risk awareness on the one hand, and simpler insurance products on the other hand, earthquake insurance could be made accessible to a wide range of stakeholders in a form that can be used to transfer the many consequences of the risk at a reasonable cost. In this way, larger parts of the population exposed to earthquakes would be better protected against the losses associated with this risk.

A bit of underwriting wisdom

Earthquake modelling challenges

Earthquake models help underwriters assess earthquake risk.

In all markets affected by recent earthquakes, models are available to underwriters that can help them assess the earthquake risk in insurance portfolios. It should be interesting for underwriters to know the key aspects of these models and how they have fared in predicting what actually happened.

Existing models have proven appropriate in predicting damage from ground shaking.

Generally, earthquake models predict earthquake shock losses well. For example the damage patterns seen in Chile, New Zealand, and Japan confirm the effectiveness of enforced building codes. Buildings designed according to the latest building code standards sustained significantly less damage than nearby historical buildings. These outcomes clearly underscore the value of enforced building codes in making buildings resistant to ground shaking. For underwriters it is also comforting to know that earthquake models anticipate this difference in building resistance.

However, earthquake models don't consider secondary loss agents enough.

However, the earthquakes in Chile, New Zealand and Japan dramatically revealed the importance of losses from secondary agents – ie losses that do not directly result from ground shaking. Secondary loss agents include tsunamis, aftershocks, soil liquefaction, business interruption (BI) and contingent business interruption (CBI). Losses from such agents contribute significantly to the overall insurance cost of events, yet they have been traditionally undervalued in loss modeling. Even today, they are not sufficiently considered in commercially available earthquake risk models.

Why secondary loss agents matter

Secondary loss agents contributed significantly to overall losses in recent earthquakes.

In New Zealand and Chile, secondary loss agents were not sufficiently considered in earthquake risk models yet they contributed significantly to overall losses. In the case of Japan and Chile, the tsunami following the earthquake resulted in a large number of fatalities and high insurance losses. In New Zealand, an effect known as liquefaction significantly multiplied the impact of the event. Aftershocks and business interruption are other "blind spots" in current earthquake models, yet their potential impact on earthquake risk assessments is considerable.

Tsunamis

Tsunami damage is a largely unexplored and often underestimated frontier of earthquake catastrophe modelling.

The Tohoku earthquake triggered a powerful tsunami wave, adding to the overwhelming and devastating impact of the earthquake. While tsunamis are no new phenomenon for Japan, the scale of the 11 March 2011 tsunami did come as a surprise. The wave height reached up to 10 meters on the coast line and ran up to 40 meters on exposed slopes in Iwate prefecture, far beyond what available risk models anticipated. Tsunami protection, in the form of sea walls and river gates, is typically designed for waves reaching a height of 3 to 4 meters along the Tohoku coastline. Furthermore, the tsunami travelled much farther inland than anticipated.

Underwriters should be aware that losses due to tsunamis are not yet included in the earthquake models for Japan and many other earthquake prone countries.

Tsunami damage in Japan is traditionally covered via earthquake insurance. Accordingly, tsunami-related claims substantially increased the cost of the Tohoku event for the insurance industry.[9] Considering that the Japanese coast line is frequently affected by tsunamis, it would seem evident tsunami risk should be considered as rigorously as earthquake risk in an insurance portfolio. However, although tsunami models have been available for some time, they have not been implemented by the insurance industry for Japan. Tsunami risk assessments should also be a standard part of an underwriter's toolkit for other tsunami-exposed markets such as Chile, Peru, Mexico, or Indonesia for example. Underwriters of earthquake risk should therefore be conscious of the possible tsunami shortcomings of existing models.

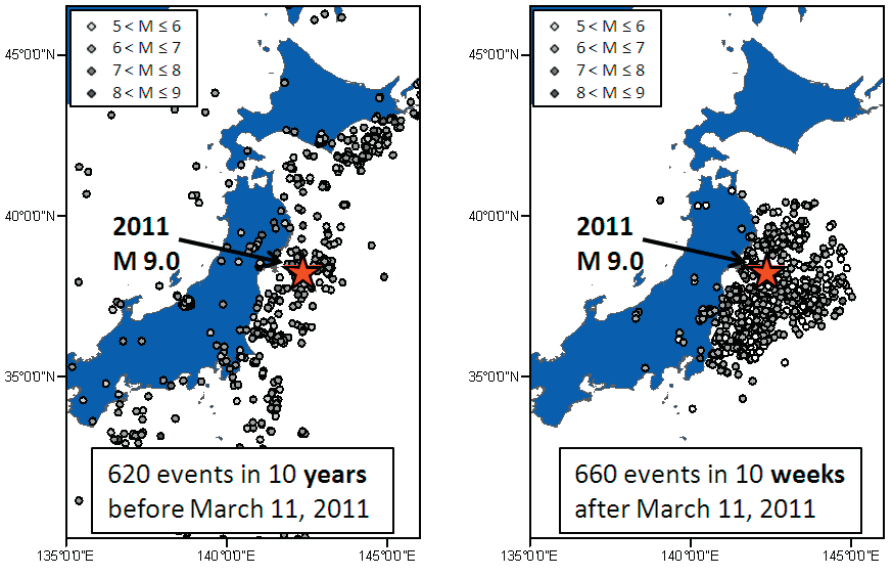
[9] According to preliminary estimates, the tsunami damage contributed 30% of overall insurance losses.

Aftershocks

The New Zealand events are testing the industry's assumptions about the scale of consecutive disasters in the same region.

It is well known that large earthquakes are followed by multiple aftershocks. For instance, Japan experienced as many Mw 5.0 magnitude aftershocks events in the 10 weeks following the 11 March 2011 earthquake as it had in the 10 years preceding the earthquake. Even now, earthquake activity in northern Honshu is still significantly higher than before 11 March. Aftershock activity following large earthquakes usually persists for a few years. For instance, the devastating Mw 9.1 earthquake in Indonesia in 2004 was followed for several years by a series of large and by themselves devastating earthquakes.

Figure 1
Earthquake activity in Japan, before and after the Tohoku earthquake. The pink star indicates the location of the epicentre of the Tohoku earthquake.



Aftershocks can cause more damage than the main earthquake.

When assessing earthquake risk, it is important to realize that available earthquake models are based on a long-term average earthquake hazard. After a large earthquake, seismicity in a region is elevated beyond the long-term average, as Figure 1 shows for Japan. As a result, earthquake models are operating "out of their comfort zone" during a time of increased aftershock activity when the actual earthquake hazard is usually underestimated. However, aftershocks pose a significant risk. The 22 February 2011 Christchurch earthquake, for instance, was, from a seismological point of view, an aftershock of the earlier earthquake on 4 September 2010. Although smaller in magnitude, the aftershock earthquake had a far more devastating impact on Christchurch than the earlier main seismological event. It also created higher losses for the insurance industry.

Aftershock sequences can easily trigger second event or stop-loss covers.

Therefore, aftershock sequences are important to consider when assessing earthquake risk. This is especially true when assessing second event covers, which only make a payout to the policy holder if the policy is affected by two or more losses. If aftershocks are neglected in the underwriting process, cover can be significantly underestimated. The same is true for stop-loss covers, which trigger when the aggregate of all event losses during the policy contract period exceed a certain deductible. For these covers as well, the presence of aftershocks strongly increases the chance of a payout to the policy holder.

Liquefaction

Liquefaction risk significantly increases reconstruction costs, and often causes total losses to property.

The 4 September 2010 and the 22 February 2011 earthquake events in New Zealand both resulted in widespread soil liquefaction. Liquefaction is a phenomenon whereby soil substantially loses strength in response to earthquake shaking, causing it to behave like a liquid. Severe structural damage usually results if liquefaction occurs underneath a building or a highway. After the New Zealand events, entire neighbourhoods were exposed to liquefaction. Many property owners are not only faced with having to repair or rebuild their homes, but also with restoring the land itself. Liquefaction often also results in property flooding because ground water is squeezed out of the soil. Another outcome, especially for large buildings, is a phenomenon called differential settlement, whereby certain parts of a building settle more than others during an earthquake, often resulting in a total loss.

The costs due to liquefaction have exceeded earthquake risk model predictions.

The costs due to liquefaction are substantial and have exceeded the predictions of available earthquake risk models. In addition to the total loss of a building, the liquefied ground has to be restored before it can again support the weight of a new building construction. Therefore, the property replacement cost consists not only of reconstruction costs but also the cost of restoring weakened soil. Furthermore, large structures in liquefaction-prone areas are usually built on pile foundations to alleviate the impact of liquefaction. Many of these structures remain intact, even after a couple of earthquake events. However, liquefaction often damages the pile foundation so that such structures are significantly more vulnerable to future earthquake events. Soil liquefaction also tends damages underground infrastructure such as water and sewage pipes.

Liquefaction is a risk in most large cities in the world, yet earthquake modellers rarely account for its effects.

Earthquake risk modellers often don't account for the effects of liquefaction, many of which have only just been observed in the aftermath of the New Zealand events. However, liquefaction is common in many earthquakes. Even the Japan earthquake in March 2011 resulted in significant liquefaction, impacting entire communities and damaging port facilities. In the case of Japan, the tsunami just happened to overshadow the effects of liquefaction by causing even more damage. However, going forward, more emphasis will be placed on identifying areas that are susceptible to liquefaction. Preconditions include a shallow ground water table and poorly consolidated sand soils. This is typically the case on reclaimed land or in flat, low-lying areas near river banks. Indeed, these preconditions apply to many neighbourhoods in most large cities around the world. Therefore, liquefaction is likely to be an increasingly big contributor to future earthquake losses.

Business Interruption (BI)

Current risk assessment models largely underestimate business interruption losses.

The size of insurance claims stemming from industrial exposure in Chile also come as a surprise, warranting a review of the way the insurance industry assesses certain industrial risks. This is especially true for business interruption (BI) covers, which compensate companies for profits loss due to production facility damage. Roughly half of the total insurance payout to industrial facilities in Chile was made for BI claims. In certain industry segments, such as pulp and paper, BI claims made up two-thirds of total claims. Large BI claims have also been observed following earlier earthquakes in Japan, where the electronics industry was impacted. They have also been observed in Turkey in 1999, where the automotive industry filed significant BI claims. Available earthquake risk models include modules to deal with BI risk. However, the BI impact is typically underestimated for industries that are highly prone to prolonged production interruptions.

Interruptions in supply chains multiply business interruption losses.

An additional challenge in assessing BI exposure stems from the definition and allocation of BI sums insured. For instance, there may be several critical locations which, if damaged, can result in a full interruption of the production chain. If the failure cannot be fixed quickly, a large BI loss will result. For instance, most ore mines rely on a land transport route to move ore to a processing location. From there, the processed ore is sent to a shipping terminal for global distribution. Any damage to a critical component in this process, such as a train, bridge, loading port, or an ore mill, will likely result in a high BI loss. Proper underwriting would reflect this potential damage by allocating the full BI sum insured to each of the critical locations. However, it is common practice to "distribute" the total BI sum insured along the value chain, thereby assuming that no failure at a critical location can trigger a full BI loss. An underestimation of BI risk is the obvious result.

Contingent Business Interruption (CBI)

CBI indemnifies a policyholder for interruptions in a supplier's facility.

Contingent business interruption, or "CBI", is an extension of traditional BI covers. A CBI cover indemnifies the policy holder for a loss in profit which is not due to damage at its own facility, but rather due to damage at a supplier's facility. The loss to the policy holder results from the lack of supplies.

The Japanese earthquake showed that a single event triggers global CBI losses, and these are largely underestimated.

The 11 March event in Japan showed that a single event can trigger global CBI covers, since key industries around the world rely on supplies from Japanese manufacturers. Some of these industries include automotive, electronics, consumer products, chemicals and pharmaceuticals. The full, interconnected scope of CBI claims is still unclear and experts estimate that it will take well into 2012 for the global claims picture to emerge. If it is difficult to assess the claims after an event, it is even more difficult to properly assess CBI risk before an event when making underwriting decisions. In addition, earthquake models typically do not offer any means to assess CBI risk.

The impact on global supply chains should be considered in earthquake risk underwriting.

CBI risk underwriters should ensure that policy wordings limit the scope of the cover. For instance, CBI policies should limit cover to named suppliers and locations where the CBI impact on the policy holder is well understood, and where the geographic scope and perils can be assessed. Furthermore, a meaningful CBI sublimit can be applied to avoid negative surprises.

Strengthening earthquake models

Underwriters should be aware of earthquake risk models' limitations.

In summary, earthquake models are a key ingredient for assessing earthquake risk. However, any decision made based on such model results should always be made with the knowledge that earthquake risk models have a number of "blind spots" that the recent events highlight. As a result, if underwriters simply consider model output, the full picture of earthquake risks tends to be underestimated. Sound decision making and an awareness of the shortcomings of existing models is therefore a key success factor for proper underwriting and risk management.

Figure 2
The major blind spots in current earthquake risk models.

Loss Driver	In models?	Yes/No
Fire following eathquake	Included in most models.	Yes
Tsunami	Not as such. A few models/markets have a slight loading on the shock rates for coastal locations.	No
Increased seismicity after large event	Not modelled.	No
Liquefaction	Some models/markets consider liquefaction. However, all models by far underestimated impact in Christchurch.	Some
Business interruption	Included in most models. However, impact for BI-sensitive industries generally underestimated.	Yes
Contigent business interruption	Not modelled. Exposure not fully understood.	No
Next surprise?	?	

Conclusion

The insurance industry proved highly effective in coping with the major disasters of the last two years.

The devastating events of the last two years serve as a stark reminder that large parts of the globe are heavily exposed to earthquake risk. However, the events have also proved that the insurance industry can function effectively, even in extreme occurrences, and that the industry plays a key role in post-disaster recovery financing. Moreover, the industry is able to provide cover despite acute financial crises, even while continuing to provide cover for many other perils.

For the industry to continue to be effective, all loss potentials must be assessed.

However, to be economically viable in the long term, insurance coverage must be able to reflect the real risk involved. Today, for continued earthquake protection coverage, an ongoing and critical review of the risk involved and the available methodologies is key. Nature has and will keep reminding us of previously neglected or underestimated loss potentials, as the recent floods in Thailand illustrate very plainly. Are all perils potentially affecting a region fully considered? If the past serves as a guide, the insurance industry tends to learn from the financially painful experience of the aftermath of costly events. In the future, however, only proactive implementation of currently neglected loss potentials, such as tsunami risk in most markets on the Circum Pacific belt, will ensure that the cost of earthquake risk is realistically assessed going forward.

A competitive and affordable insurance market can lower economic vulnerability to earthquakes.

A competitive and affordable insurance market, one which nevertheless truly reflects the risk involved, is key to providing continued coverage. For premiums to remain affordable, they must be spread amongst a higher portion of the population and business owners. This will only be possible once earthquake risk awareness is raised. Only then will earthquake insurance remain economically viable for the insurance industry, and only then will the insurance industry be able to keep playing a key role in risk mitigation and in post-disaster recovery financing of earthquakes.

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