Assurances et gestion des risques
Insurance and Risk Management

THE DUAL INSURANCE MODEL AND ITS IMPLICATIONS FOR INSURANCE DEMAND AND SUPPLY POST-CHRISTCHURCH EARTHQUAKES IN NEW ZEALAND

Richard K. Mumo and Richard Watt

Volume 83, Number 3-4, 2016

URI: https://id.erudit.org/iderudit/1091506ar
DOI: https://doi.org/10.7202/1091506ar

See table of contents

Publisher(s)

Faculté des sciences de l'administration, Université Laval

ISSN

1705-7299 (print)
2371-4913 (digital)

Explore this journal

Cite this article

Mumo, R. & Watt, R. (2016). THE DUAL INSURANCE MODEL AND ITS IMPLICATIONS FOR INSURANCE DEMAND AND SUPPLY POST-CHRISTCHURCH EARTHQUAKES IN NEW ZEALAND. *Assurances et gestion des risques / Insurance and Risk Management*, *83*(3-4), 135–166. https://doi.org/10.7202/1091506ar

Article abstract

This paper gives an empirical analysis of the insurance reactions post-Christchurch earthquakes of 2010-2011. In a broad sense, the paper examines the earthquakes' ramifcation for the supply-side of the entire insurance industry in New Zealand as well as going further to give a narrow analysis of the implications for individual insurance companies. The research has been motivated by the unique attributes of the New Zealand natural disaster insurance scheme. This has helped private insurance companies to provide insurance coverage at competitive premium rates even when the probability of a catastrophic event is considered high in New Zealand. The study starts with a market analysis that points to the need for government intervention in natural disaster insurance provision in countries prone to disasters. The paper illustrates the framework for natural disasters in New Zealand as well as giving supply-side changes that were experienced in the aftermath of Christchurch quakes.

Assurances et gestion des risques, Vol. 83 (3-4)
Insurance and risk management, Vol. 83 (3-4)

THE DUAL INSURANCE MODEL AND ITS IMPLICATIONS FOR INSURANCE DEMAND AND SUPPLY POST-CHRISTCHURCH EARTHQUAKES IN NEW ZEALAND

Richard K. Mumo[1], University of Canterbury
Richard Watt[2], University of Canterbury

ABSTRACT

This paper gives an empirical analysis of the insurance reactions post-Christchurch earthquakes of 2010-2011. In a broad sense, the paper examines the earthquakes' ramification for the supply-side of the entire insurance industry in New Zealand as well as going further to give a narrow analysis of the implications for individual insurance companies. The research has been motivated by the unique attributes of the New Zealand natural disaster insurance scheme. This has helped private insurance companies to provide insurance coverage at competitive premium rates even when the probability of a catastrophic event is considered high in New Zealand. The study starts with a market analysis that points to the need for government intervention in natural disaster insurance provision in countries prone to disasters. The paper illustrates the framework for natural disasters in New Zealand as well as giving supply-side changes that were experienced in the aftermath of Christchurch quakes.

RÉSUMÉ

Cet article offre une analyse empirique de la réaction des compagnies d'assurance suite aux tremblements de terre de Christchurch de 2010-2011. L'article examine l'impact de ces événements sur l'offre d'assurance pour l'ensemble de l'industrie en Nouvelle-Zélande ainsi que pour les compagnies d'assurance individuelles. Cette étude est motivée par la structure unique d'assurance pour catastrophes naturelles en vigueur en Nouvelle-Zélande. Ce montage est tel que les primes ont pu demeurer compétitives malgré le risque élevé de catastrophe naturelle dans le pays. L'étude débute par une analyse de marché démontrant le besoin d'intervention du gouvernement dans les pays avec risque élevé de catastrophes

naturelles. L'article illustre le mode de fonctionnement de l'assurance pour catastrophes naturelles en Nouvelle-Zélande tout en montrant les changements d'offre d'assurance suite aux tremblements de terre de Christchurch.

Keywords: Christchurch Earthquake; Insurance; Loss Ratio; Premium; Catastrophe

JEL Classification Numbers: G22, G28, D81, H84

1. Introduction

1.1 Overview

This paper looks at the empirical implications of earthquakes for insurance markets. The research is centered on the supply-side of the insurance market post-Christchurch earthquakes. The analysis starts by first introducing the events leading to the Christchurch catastrophes. Second, the study looks at how catastrophe risks are insured in New Zealand by giving a diagnostic analysis of the natural disaster insurance market for residential property and contents. Third an empirical analysis is carried out using data sets of business statistics in all business lines and also for particular classes of business, namely domestic building and contents. Lastly, the role played by governments in provision (and/or interventions) and how this has helped both private insurance and reinsurance providers to meet the reasonable expectations of customers is described.

In summary then, the most interesting contribution in the paper is the description of what happened in the New Zealand insurance market post-Christchurch earthquakes. That is, (i) the change in contracts from full replacement cost to sum insured and the effect of this change on the insurance market, (ii) the rise in the premium rate and why the premium changed, (iii) the increase in the total amount of premiums written showing business growth; to what extent this depended on the increase in premium rates, changes in contract formation or changes in property value, and (iv) the values of the loss ratio pre- and post-quakes.

1.2 Introductory Background of Events Leading to Christchurch Earthquakes

Over 20,000 earthquakes are recorded by New Zealand's geological hazard monitoring system (most of them being minor) every year, with approximately 200 of them being strong enough to be felt. In 2010 and 2011, two major earthquakes occurred in Christchurch. In particular

the first strong quake at a magnitude 7.1 on the Richter scale occurred at 4:35 am on September 4, 2010.The epicenter was 40 km west of Christchurch City and the depth of the quake was at 10 km (Wu, Cheung, Cole, & Fink, 2014). In the aftermath of the first earthquake, dozens of its aftershocks followed, causing moderate damage. The first earthquake sequence initiated three other significant earthquakes close to the city of Christchurch culminating in an aftershock which was the second major earthquake, measuring 6.3 on the Richter scale, and which struck at 12:51 pm on February 22, 2011. The location of the second major quake was within 5 km south-east of Christchurch, at a shallow focal depth of 5 km (Wu et al., 2014). This second quake produced damage labeled as destructive by GeoNet (the builder and operator of modern geological hazard monitoring systems in New Zealand); unreinforced masonry buildings were severely damaged with liquefaction occurring in many parts of the eastern suburbs rendering entire neighbourhoods completely uninhabitable (Buchanan, Carradine, Beattie, & Morris, 2011; Bull, 2013).

TABLE 1 *Five major canterbury earthquakes*

TIME	LOCATION	MAGNITUDE	INTENSITY
4:35 am, September 4, 2010	840M from Ansons Road, Charing Cross	7.10	X
10:30 am, December 26, 2010	40M from Brougham Street, Sydenham, Christchurch	4.91	V
12:51 pm, February 22, 2011	340M from Rapiki Road, Hillsborough, Christchurch	6.34	VIII
2:20 pm, June 13, 2011	690M from Barnett Park Track, Redcliffs, Christchurch	6.41	VIII
3:18 pm, December 23, 2011	250M from 466-68 Marine Parade South New Brighton, Christchurch	6	VII

Source: (GeoNet 2014)

Estimates of the total economic cost of the two earthquakes vary and are subject to considerable uncertainty. The biggest challenge was the ongoing nature of the earthquake sequence, and the need to treat each of the 5 major separate events (see Table 1), identified by the Earthquake Commission (EQC) as being independent events that could be claimed for individually.

Until the full payment of all claims and complete recovery is done, it remains a difficult task to give an exact figure for the total economic cost and insured losses paid out. There have been differences between the market value of assets destroyed, the cost of replacing those assets over time, and the additional value of rebuilding to a higher standard or other discretionary improvements. In addition, disruption to businesses and to the lives of individuals following a natural disaster can be substantial, but it is difficult, if not impossible, to measure the financial implications of all of these effects accurately. The Christchurch earthquakes provided an unprecedented challenge for the insurance industry and indeed to the entire New Zealand economy. The New Zealand Treasury estimated the total cost of insurance claims for the earthquakes at a value above NZ$30 billion, which is equivalent to 15 to 20 per cent of the Gross Domestic Product GDP (Kachali et al., 2015; Parker & Steenkamp, 2012).

Taking into account the complications with claims involving multi-unit buildings, retaining walls and land issues, the private insurers had paid out NZ$17.8 billion in settling claims resulting from the Christchurch earthquakes in 2010 and 2011 as at the end of March 2016. The payments were comprised of NZ$9.6 billion paid to settle commercial claims and NZ$8.2 billion for domestic claims. This represented a significant contribution towards the new estimated NZ$40 billion economic loss suffered in the Canterbury region. This has allowed businesses and households to recover and rebuild almost five years after the tragedy. The figure includes damages to buildings and contents, as well as disruption to business activities but does not include underinsured or uninsured losses (Brookie, 2014; Kachali et al., 2015). The fact that natural disasters have both immediate and long-term economic effects has not been captured in any of these estimates; it is therefore prudent for this study to conclude that the actual economic impact is much higher. An early estimate by Aon Benfield had put the Christchurch earthquakes amongst the most significant natural disaster events in the insurance world, with insurance losses initially estimated at US$13.5 billion. Later in 2013 these estimates were adjusted to US$16.5 billion and now the figure stands beyond US$40 billion, according to the Reserve Bank estimates(Parker & Steenkamp, 2012; Potter, Becker, Johnston, & Rossiter, 2015).

Table 2 indicates the top ten insurance loss estimates from natural disasters worldwide in 2011; the losses from the Christchurch quakes, even at the most conservative figures, stood at position two worldwide in the year ending 2011 (Swiss-Re, 2012).

TABLE 2 *Christchurch earthquakes compared to global events in 2011*

TOP TEN INSURANCE LOSS EVENTS IN 2011	ESTIMATED LOSSES IN $ (USD)
Earthquake Japan	35.00 billion
Earthquake New Zealand, 22 February 2011	13.50 billion
Flooding Thailand	10.78 billion
Severe Weather U.S. Southeast, Plains, Mid-West	7.30 billion
Severe Weather U.S. Plains, Mid-West, Southeast	6.75 billion
Severe Weather Hurricane Irene	5.00 billion
Flooding Australia	2.42 billion
Severe Weather U.S. Southeast, Plains, Mid-West	2.00 billion
Earthquake New Zealand, 22 December 2011	1.80 billion
Severe Weather U.S. Plains, Mid-West, Southeast	1.70 billion

Source:(Aon/Benfield, 2013)

The Swiss-Re 2012 Sigma report shows that the reinsurance industry in 2011 suffered one of the highest, if not the highest, insured losses ever. That year also saw the tsunami in Japan, an active windstorm season in North America and Thailand and floods in Queensland. As a result, there was a tightening of the reinsurance market, leading to a very significant increase in reinsurance costs. The costs were global and translated into a significant increase in premiums for households in New Zealand in comparison to other nations prone to natural disasters.

The paper proceeds in eight sections as follows: in the next section, we present in general the challenges faced post-quakes, and the role of the government in natural disaster insurance. Section three describes the New Zealand natural disaster insurance scheme through the Earthquake Commission (EQC). New Zealand ranked second highest for non-life insurance penetration relative to GDP and with residential insurance penetration at above 90%, this section discusses how the high penetration of insurance in the residential market can largely be attributed to the fact that New Zealand is ranked third in the world for expected losses and to the program offered by the EQC. In section four, the study reviews the literature of government involvement in natural disaster insurance programs worldwide. Section five expounds on the description introduced in section three to demonstrate how the EQC versus private insurance company's dual insurance model framework

is structured. This section also describes the reinsurance market for New Zealand catastrophe risk and goes further to introduce a concept that can be used as an alternative to the traditional reinsurance mechanisms currently used the insurance market. Section six uses industry business statistics to describe the supply-side reaction and the impacts on the insurance market post-Christchurch earthquakes. Section seven gives a further government intervention analysis for the case of "red-zone"[3] state property acquisition. The analysis of the state settlement of red-zone properties and the choices made by the homeowners reveals the importance of state intervention in extreme natural disaster events and the insured perception thereof, and the decisions and choices that can be made when faced with the situation of the state taking over all insurance claims for damage to property. In this analysis, the study aims to describe the circumstances in which the insured find themselves when their properties are deemed unfit for habitation and the prevailing choice parameters involved. Section eight gives a further general observation on the market reaction post-Christchurch earthquakes in line with the prior literature. The last part of the paper concludes with a brief discussion on the findings of the study.

2. Natural disaster insurance

2.1 Need for Government Participation in Natural Disaster Insurance

Table 2 in Section 1.2 illustrates how devastating natural disasters can be to the normal operations of an economy. The magnitude of the economic shock from catastrophes can thus never be left to the traditional insurance mechanism to fully protect the economy and to rebuild society back to smooth daily affairs. Thus; insurance for natural disasters is not a matter to be left to the private insurance players alone. This study demonstrates that, for an insurance market faced with catastrophe exposure, if this were to happen, private insurers would require premiums which are unaffordable to the insured. In the end this leads to market failure as suggested in Nguyen, (2013). In order to avoid the insurance market inefficiency due to extremely high premiums, government-sponsorship (or subsidies) is hence necessary. In cases of no state participation or subsidies, private insurance markets would totally collapse because of exposure to extreme catastrophes.

Thus, in countries prone to specific natural disasters, governments have found it necessary to intervene in insurance provision. While the participation in insurance solutions in form of state sponsored insurance programs differ in principle, generally they are all designed to

offer insurance to individuals (mostly homeowners) who would otherwise find it unaffordable to buy policies in the private insurance market. The government and the private insurance companies can further participate in elaborate reinsurance mechanisms to cede part of the underwritten risk.

The next section demonstrates how natural disaster risk is insured in the New Zealand residential property and contents market together with a brief literature on countries with similar State-sponsored systems.

2.2 New Zealand Natural Disaster Insurance through the Earthquake Commission

In a study of 42 high risk countries in 2011,New Zealand ranked second highest for non-life insurance penetration relative to GDP (with premiums equivalent to 5.2% GDP) and highest in the world in the residential insurance penetration (CEBR, 2012). Although the residential insurance penetration is very high in New Zealand – over 90% –earthquake insurance penetration in general is about 80%, as compared to that in North America at 20%; virtually everyone has an insurance policy protecting their home (Pierepiekarz et al., 2014). In other parts of the world, underinsurance continues to be a problem. For example, only 17% of the economic losses of Japan following their 2011 tsunami were covered by insurance (Cooper, Donnelly, & Johnson, 2011; Marquis, Kim, Elwood, & Chang, 2015). The high penetration of insurance in the residential market can largely be attributed to two factors; (1) the fact that New Zealand is ranked third in the world for expected losses that could occur from a natural disaster as a percentage of GDP in any given year (Brown, Seville, & Vargo, 2013), and (2) the program offered by the EQC. The EQC is a Crown entity that has its origins in an insurance pool set up in 1941 to address war damages. It was later expanded to cover earthquake damages and in 1993 became the EQC. The EQC provides natural disaster cover for buyers of residential insurance provided by private insurers. This is a unique natural disaster insurance scheme which is provided as a rider[4] on fire and general peril cover offered by the private general insurance market in New Zealand. Therefore, all residential property owners who buy fire insurance automatically acquire EQC Insurance. Under the domestic building and contents insurance cover provided, all general insurers in New Zealand collect a levy on behalf of the EQC. As important as it is to homeowners, those who do not buy private insurance cover for their residential properties for whatever reason do not receive this EQC cover.

The EQC's main function is to insure residential properties, their contents and the land around the properties against damage by earthquake, volcanic eruption, natural landslip, hydrothermal activity, and tsunami. The cover also includes fire following any of these disasters and residential land damaged by storm or flood. In addition to managing the fund, EQC buys international reinsurance and is government guaranteed. This provides assurance to insurance consumers that if EQC has a very large number of claims and cannot cover its obligations from the natural disaster fund and its reinsurance, then the government will pay the shortfall as the reinsurer of last resort.

Through its natural disaster fund, cover is provided for residential properties to a maximum of NZ$100,000 excluding GST,[5] and contents to a maximum of NZ$20,000 excluding GST. This amount of insurance is available for each event of natural disaster damage. From February 1, 2012, the EQC levy on residential property and contents insurance increased from 5c to 15c per NZ$100 of insurance cover (this is equivalent to 200% increment). The maximum total levy that a policy holder pays per-residence is now at NZ$150 for home policies and NZ$30 for contents policies, (excluding GST). The most a policyholder can pay as levy, per year, for one home and its contents is therefore NZ$180 excluding GST. The levy is normally loaded to the underwriter's premium and passed on to EQC once the premium is received by the insurance company. The increases applied if the policyholder took out new residential property and contents policies on or after 1 February 2012 or had an existing annual policy with a renewal date within the 12 month period from 1 February 2012.

A possible explanation to the increment is an intention to help rebuild the EQC's natural disaster fund following the Christchurch earthquakes and to ensure that the EQC has the capacity to meet its obligations in the future as well as to cope with the new reinsurance underwriting requirements. Private non-life insurers provide natural disaster damage cover to a level beyond the maximum cover that EQC provides. This is often referred to as EQC top-up cover.

2.3 Natural Disaster Insurance Programs Worldwide With Government Involvement

Literature from previous studies (Aseervatham, Born, Lohmaier, & Richter, 2015; Atreya, Ferreira, & Michel-Kerjan, 2014; Grace & Klein, 2003; Grossi, Kunreuther, & Patel, 2005; Klein & Kleindorfer, 1999) points to the fact that State participation in insurance markets is not only unique to New Zealand. The National Flood Insurance Program

(NFIP) managed by the Federal Emergency Management Agency (FEMA), California Earthquake Authority (CEA) and Japanese Earthquake Reinsurance (JER) have similar natural disaster programs, while Turkey has one of the newest such programs now in place. However, the unique features of EQC in New Zealand's government involvement reveal the greater semi-autonomous role that States could play in the private insurance market.

In the US, standard homeowners insurance doesn't cover flooding and associated natural hazard perils. The federal government established the NFIP in 1968 (Dacy & Kunreuther, 1969; Michel-Kerjan & Kousky, 2010) to help provide a means for property owners to protect themselves financially from the floods associated with hurricanes, tropical storms, heavy rains and other conditions that heavily impact some states in the US. Managed by the FEMA which maps flood risks and sets flood insurance premiums, the programme is designed as a voluntary partnership between the federal government and local communities. The NFIP provides insurance up to a maximum limit for residential property damage, now set at US$250,000 for building coverage and US$100,000 on contents coverage. The underlying principle of the program is to subsidise the cost of flood insurance on existing homes, in order to maintain property values, while charging actuarially fair rates on new construction. Similarly, the California Earthquake Authority (CEA) established by the California legislature in 1995 following the 1994 Northridge earthquake, is designed to preserve the state-mandated offer of earthquake coverage. The CEA required the participation of 70% of California homeowner insurers before it could begin operation. Insurers choosing not to participate are required to offer a similar brand of earthquake coverage to residential policyholders. The CEA offers a scaled-down policy covering homes and certain apartment buildings, but not other structures such as swimming pools, garages and driveways. Unlike New Zealand's EQC no public funds are pledged or available to cover CEA-insured losses. If an earthquake causes damage greater than the CEA's claims-paying capacity then policyholders will be paid on a prorated basis. The prorated claims would be calculated on the basis of the total amount of expected claims compared to the remaining available funds.

Elsewhere in Japan, the 1966 Earthquake Insurance Law (enacted after the Niigata earthquake of 1964) established the Japanese Earthquake Reinsurance (JER), to whom private nonlife insurers were obliged to offer earthquake insurance and cede 100% of the earthquake premium and liabilities (Tsubokawa, 2004). The JER thus acts as the sole earthquake reinsurer for the private insurance market. The total

claims-paying capacity of the program is currently ¥5,500 billion (US$45 billion), which is estimated to correspond to the scenario of the 1923 Great Kanto earthquake with a return period of 220 years. In the event the insured earthquake losses exceed this amount, claims would be prorated accordingly. The maximum liability of the government of Japan, JER, and private insurers is 87%, 10%, and 3%, respectively.

In the aftermath of the two major earthquakes in 1999, the Government of Turkey decided to enforce earthquake insurance on a nationwide basis with the sole purpose of privatising the potential risk by offering insurance via the Turkish Catastrophic Insurance Pool (TCIP). This program bundles the major part of disaster risk and exports it to the international reinsurance and capital markets (Bommer et al., 2002). This measure was aimed at reducing government's fiscal exposure in the event of major catastrophic earthquake, as well as to encourage risk mitigation and safer construction practices. To achieve these goals all registered residential properties in Turkey (the total number currently is about 19 million) are required to be in the compulsory earthquake insurance coverage.

Initially funded by the World Bank, the TCIP program became effective as of March 2001 and is currently one of the most renowned insurance brands in the Turkish insurance market. High brand recognition and increasing earthquake insurance awareness among homeowners gives leverage to take-up rate in earthquake insurance (TCIP policy count was about two million as of September 2004, increasing to 7 million by end of 2014). The TCIP policy offers coverage on a first-loss basis, meaning that it does not impose underinsurance penalties when the value of a dwelling is significantly higher than the limit of coverage obtained from the TCIP. Unlike the CEA, which imposes a deductible of 10%, the TCIP applies a minimum 2% deductible to the sum insured to avoid small claims, reduce moral hazard and reduce the pools' administrative and reinsurance costs.

This study examines examples of three state-sponsored programs to emphasize the central important role played by such programs in the natural disaster insurance. An audit of governments' involvement in insurance provision worldwide set New Zealand as the only country with unique compulsory natural disaster fund to only those who buy private home insurance cover and 100% government guaranteed. The role played by the EQC in the aftermath of Christchurch quakes cannot be understated; without the EQC, it would be almost impossible for the private insurance to singlehandedly rebuild Christchurch City back to normalcy.

3. The Dual Insurance Model Framework In New Zealand

This section examines the structural framework and formation of the natural disaster insurance in New Zealand. In the aftermath of the 2010 and 2011 Canterbury earthquakes, questions have emerged on whether the dual-insurance model in New Zealand for earthquake claims worked as was envisaged by EQC and the wider insurance industry. This section deduces how such risks are underwritten, which lays a foundation for natural disaster specific risk rating and proposes an alternative risk hedging mechanism that can be explored together with the existing traditional reinsurance arrangements. It is now clear that the New Zealand residential property and contents insurance is made up of two layers of insurance contracts running in a dual-insurance model. As described in the preceding section, the first contract layer is covered by EQC, and the second contract layer is covered by the private insurance market. The EQC cover is against natural disaster perils to a prescribed policy cap in return for a premium, a statutory levy charged to all residential property fire and general underwritten premium rates.

An outlook of the contract for this insurance arrangement is given as follows. Suppose the proportion covered by EQC contract is up to a predetermined sum insured denoted by Q (now set at a maximum of NZ$100,000 excluding GST for residential properties and to a maximum of NZ$20,000 excluding GST for contents). The second component of the contract covered by the private insurer to a maximum sum insured is denoted by M. The primary insurer is in this case responsible for any claim cost associated with random loss X, if and only if the gross loss amount is between Q and the maximum nominated sum insured M subject to all other policy conditions within the contracted period denoted as T (i.e. provide indemnification per occurrence for losses X that exceed the EQC level Q and given that it is less or equal to M). Thus, we present the above insurance arrangement as follows:

(i.) If $X < Q$ then the primary underwriter pays nothing;

(ii.) If $Q < X \leq M$ then the primary underwriter pays $X - Q$; and

(iiii.) If $X > M$ then the underwriter pays $M - Q$ and the exceeding potion $X - M$ is borne by the homeowner.

For an insurance pay-out denoted by P, the above contractual agreement on the insurers' side is as follows:

$$P = \begin{cases} Min(X - Q, M - Q) & for\ Q < X \\ 0 & elsewhere \end{cases} \qquad Eq\ 1$$

Eq 1 presents the contract formulation that forms the basis for pricing the liability undertaken by the EQC. Currently, the EQC imposes a blanket levy across all residential property buying insurance coverage based on actuarial pricing of a totally different risk category (i.e. fire and general peril). In this study it is proposed that the levies could be based on the actual risk factors based on *Eq* 1 that have relevancy to the occurrence of natural disasters as opposed to a fixed levy on the premiums for totally different risks. Second, *Eq* 1 can as well be re-expressed as the difference between two call options with different exercise price, that is, a call-option spread, written on the loss exposure of the underlying event as suggested in (Cummins, Lewis, & Phillips, 1999):

$$P = Max(0, X - Q) - Max(0, X - M) \qquad Eq\ 2$$

As an alternative to traditional reinsurance arrangements the EQC together with the private insurers could write a hedging contract which could be tradable in a derivatives market. Under the current residential insurance structure shown by *Eq* 2, the EQC and insurance providers can directly write and sell contingent claims against the upper cap of natural disaster losses on a per-occurrence basis and trade in the Catastrophe Bond & Insurance-Linked Securities.

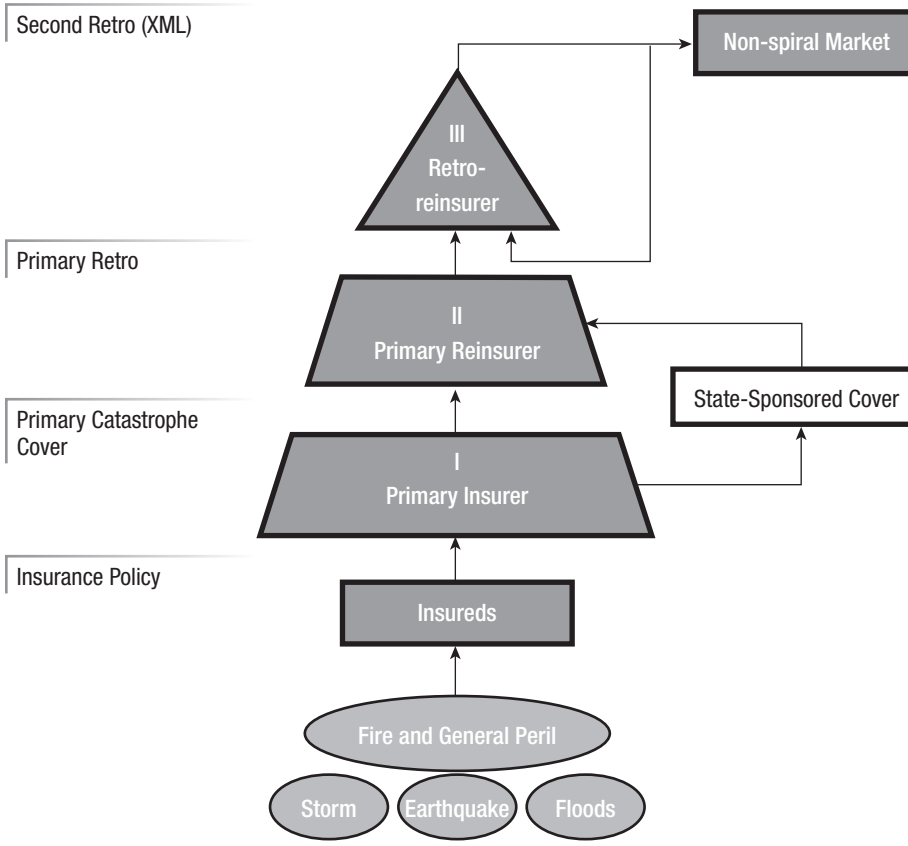
This study finds that the key to success of property insurance in New Zealand even with such high catastrophe risk is the elaborate reinsurance arrangements in place. Lead by the syndicates at Lloyd's of London the crucial role played by the reinsurance market post-Christchurch catastrophe cannot be overstated. The complex structure of the reinsurance arrangement is shown in Figure 2, which depicts the stages in the catastrophe insurance market through which New Zealand natural disaster business is insured. This is grouped into three levels (i.e. primary insurers, primary reinsurers and retro-reinsurers) based on their position in the chain of insurance and reinsurance buyers and sellers.

On Level I are the primary insurance companies that issue homeowners policies (i.e. fire and general peril with natural disaster bundled as a rider). The direct writers in turn purchase reinsurance contracts normally referred to as "catastrophe cover" from primary reinsurers on Level II.

On Level II are companies such as large professional reinsurers, many syndicates at Lloyd's of London as well as large and small broker market reinsurers worldwide. Some reinsurers specialise in this business. Typically, those companies would be leads[6], who would quote terms on contracts which other companies would then follow (that is,

sign on to). Occasionally and more-so in highly catastrophe prone markets, reinsurers directly influence the premium rate and other policy conditions at level I. For example, the Christchurch earthquakes led to a switch from total replacement home insurance to sum insured: for reinsurers to better understand their maximum liability for residential properties in New Zealand.

FIGURE 1 *Structure of natural disaster insurance and reinsurance transfer*



On Level III are companies who reinsure the primary reinsurers. They provide catastrophe cover referred to as "primary retrocessional contracts" for the primary reinsurers. Although many of the primary reinsurers will write a handful of these primary retro contracts, the number of companies that specialize in and write a significant volume of this business is a small sub-set of the universe of reinsurers. Some syndicates at Lloyd's are specialists in this type of business. These companies on Level III themselves buy secondary retrocessional

catastrophe cover referred to as "LMX" (London Market Excess of Loss business). There is not a distinct fourth level of companies writing these, but they are written by a subset of Level III companies themselves. This study finds that an estimated 37% of Lloyd's total business in reinsurance has most relevance to New Zealand. Gross written premiums amounting to NZ$340 million is generated from New Zealand customers each year. This places the market at position 47 amongst the 200 countries Lloyd's business works in (Franco, 2014). In this light, on Wednesday, February 18, 2015 Lloyd's of London Chairman John Nelson made his first visit to Christchurch, a manifest of the importance of New Zealand market to the syndicates and the fundamental need for catastrophe insurance cover.

As at April 2015, the Lloyd's syndicates had paid out NZ$4.2 billion of reinsurance and insurance claims for two Christchurch earthquakes. This figure was estimated to increase to NZ$5.8 billion as further reinsurance payments are paid to EQC and others (King, Middleton, Brown, Johnston, & Johal, 2014; Merkin, 2012).

4. Insurance Market Post-Quakes

4.1 Some Literature On Post Disaster Reactions

Prior literature points out that when insurers' risk-taking capacity as determinant for the insurers' willingness to provide coverage is strictly disrupted, see Cagle & Harrington (1995), Gron (1994), Harrington, Niehaus, & Yu (2013) and Winter (1994), a reduction of insurance supply immediately after major catastrophic losses is predictable. However, Cagle & Harrington (1995) and Ragin & Halek (2015), suggest that the price effect of a negative shock to capital depends on the price elasticity of demand. And therefore insurers' ability to recover from a catastrophic loss by increasing insurance premiums is limited when policyholders respond to prices and especially when there are recent bankruptcy cases in the industry in the aftermath of a disaster. (P. Born & Viscusi, 2006) observe a negative supply effect of both large and unexpected catastrophes and that insurers are able to improve their loss ratios in the medium term after large catastrophes by raising insurance premiums. These shift the cost of a capital shock to the policyholders resulting to depressed demand. Klein & Kleindorfer (1999) and Grace & Klein (2009) who investigate the impact of hurricanes on the Florida insurance market documented similar results. They found an increase in prices and a decrease in availability of insurance coverage due to the increased hurricane risk. Grace, Klein, & Liu (2005) examine insurance market reactions after the catastrophic hurricane seasons of

2004 and 2005 and identify three major effects on insurance supply. Firstly, a reduction in insurers' and reinsurers' capital due to the loss shock, secondly an increase in the volatility of insurers' net income which aggravates the take-up of new capital due to an increase in risk. Lastly, a disruption of insurers' own confidence in risk assessment (or risk models) which reduces the willingness to write new business. Browne & Hoyt (2000) provide the first empirical analyses of home-owners' demand for flood insurance through a state-level analysis across the US. Their empirical analysis suggests that both price and income are influential factors in one's decision to purchase flood insurance, and flood insurance purchases at the state level are found to be highly correlated with the losses in the state during the prior year. Kousky (2010) examines the demand for flood insurance in St. Louis, Missouri and found that take-up rates increase with more land in the high risk floodplains, and the rates decline with levee protection along major rivers. However, most of these papers have not examined the supply and demand for insurance contracts post major catastrophic events holistically at the primary level where the direct insurers, individual insured and reinsurers interact. Grace, Klein, Kleindorfer, & Murray (2003) point out that, analysing the supply and demand for residential property insurance after a mega-disaster and integrating this analysis with research on risk diversification and mitigation, is critically essential, in order to formulate a more complete picture of the catastrophe risk problem and evaluating viable solutions.

4.2 Insurance Industry Reaction Post-Christchurch Earthquakes

This section examines the post-quakes reaction on the supply-side. The main objective is to show how the 2010-2011 earthquakes impacted the performance of the insurance market. The study has gathered data from the Insurance Council of New Zealand (ICNZ) and one private insurer for the purposes of this analysis. The data from the ICNZ give a broader representation of the business statistics of both the entire industry and a specific class of interest from 2008 to 2015. This information is published annually by the ICNZ (the Council currently has 28 members who collectively write more than 95 percent of all fire and general insurance in New Zealand). Using the data, the study gives a brief analysis of how New Zealand's insurance business statistics as well as any noticeable reactions in the aftermaths of the Christchurch earthquakes. The second set of data comes from a private insurance company for the period 2006 to 2014. In order to give a clear and coherent description of the reaction of the insurance companies involved in the Canterbury region residential property and contents insurance market, this section gives a descriptive analysis of the two data sets.

In the end, this study aims to illustrate the implication of the two earthquakes to the normal daily operations of insurance markets. The major obstacle this research is gripped with was the unwillingness of many organisations to share data. So an opportunity to rigorously analyse the insurance market pre-quakes has been missed which would otherwise inform this study of the trends and market dynamics.

The following table provides an outline of the New Zealand insurance market for the period 2008-2015 (September Year End). In particular, it outlines the gross written premium for Insurance Council members and the claims incurred by members for each year. It does not include ACC, the EQC or business placed into offshore markets. As a consequence the balance between different classes of business as shown following will be in different proportions to that which might be seen in other overseas insurance markets.

TABLE 3 *All Business ($ Millions) 12 months to September*

YEAR-END	2008	2009	2010	2011	2012	2013	2014	2015
Gross Written Premium ($)	3,260	3,417	3,604	3,980	4,449	4,770	5,258	5,261
Net Written Premium ($)	2,808	2,911	3,119	3,179	3,462	3,653	4,018	3,880
Net Earned Premium ($)	2,748	2,857	3,073	2,962	3,247	3,507	3,912	3,896
Claims Incurred ($)	1,881	1,845	2,097	3,312	2,206	2,175	2,350	2,546
Loss Ratio (%)	68.46%	64.59%	68.22%	111.81%	67.94%	62.03%	60.07%	65.35%
Business Costs (Staff etc) ($)	898	941	997	1,023	1,006	1,201	1,315	1,367
Combined Ratio (%)	101.13%	97.53%	100.66%	146.36%	98.93%	96.27%	93.69%	100.45%

Source: (Insurance Council of New Zealand 2016)

Note: Where the Combined Ratio exceeds 100% insurance Council members have made a loss in the 12 months reporting period.

Figure 2 shows a plot of all business, with a spike between 2010 and 2012 incurred claims. This sharp spike is attributed the claims in the aftermaths of the quakes.

FIGURE 2 *NZ insurance industry all business data for the period 2008-2015*

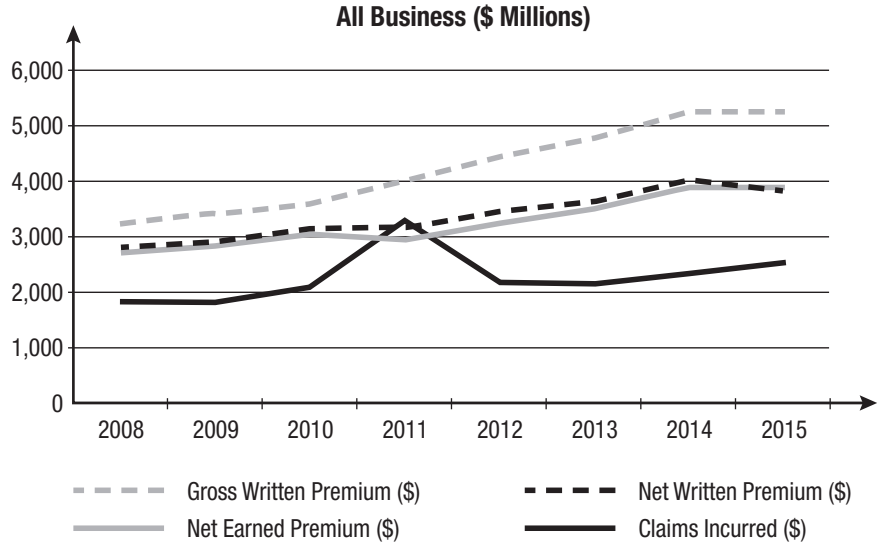


Table 4 and figure 3 outline the gross written premium for each separate business class, firstly on a numerical and then a percentage basis.

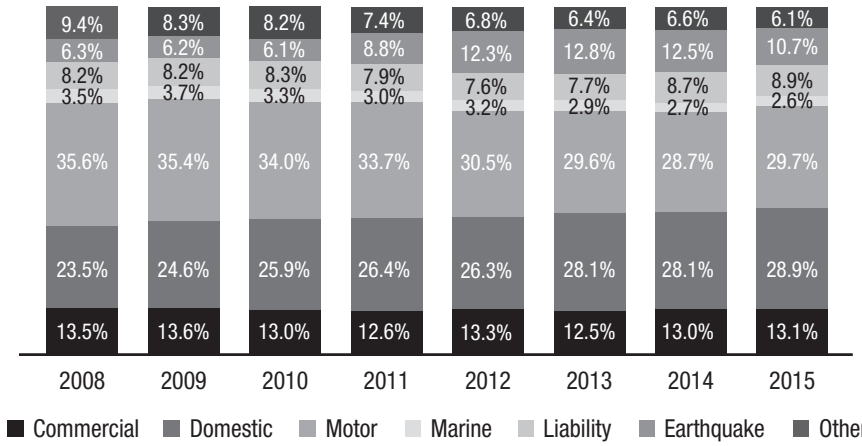
TABLE 4 *Gross written premiums of business classes ($ Millions) 12 months to September 2008-2015*

YEAR-END	2008	2009	2010	2011	2012	2013	2014	2015
Commercial ($)	441	464	469	502	590	598	684	687
Domestic ($)	766	840	933	1,052	1,170	1,342	1,477	1,522
Motor ($)	1,159	1,210	1,226	1,340	1,355	1,410	1,509	1,564
Marine ($)	114	126	120	120	144	137	141	137
Liability ($)	267	280	298	314	338	369	457	468
Earthquake ($)	207	213	220	350	549	609	643	561
Other ($)	306	283	297	296	303	305	347	321
Total ($)	3,260	3,417	3,604	3,980	4,449	4,770	5,258	5,261

Source: (Insurance Council of New Zealand 2016)

A general analysis of ICNZ data broadly reveals that the premiums for New Zealanders are driven by a number of factors including domestic market competitiveness and how global capital market changes influence reinsurance. The industry all business data for the last five years indicate the amount of money used for insurance has increased. For example, domestic and earthquake insurance business class has been on an increasing trend with Earthquake Insurance doubling from an annual business proportion of 6.3% in 2008 to12.2% in 2014 and then a slight decrease to 10.7% in 2015 (see Figure 3). In dollar terms, the aftermaths of the quakes the gross written premiums[7] for earthquake insurance has grown three fold from $207M to $561M. Domestic Buildings and Contents Insurance also recorded a similar increasing trend on an annual business proportion of 23.5% in 2008 to 28.9% in 2015. Figure 3 and the data in Table 4 show Earthquake Insurance and Domestic Buildings and Contents Insurance being the only two lines of businesses that recorded a continuously increasing gross written premium between the periods 2010 to 2015. Despite the fact that other business lines recorded some growth in premium, each class growth was decreasing as a proportion of the entire insurance business.

FIGURE 3 *Gross written premiums of business classes 12 months to september 2008-2015*



The study postulates that the increase in premiums can be interpreted in three ways; first, it can be assumed that the demand for these two classes of business has been sharply increasing since 2010; second the increase in gross written premiums can be attributed to increases in the premium rates (both insurer and reinsurer rates) in the aftermath of the 2010-2011 earthquakes and third increase in government levies and the need to build-up capital reserves.

This study sets itself the objective ofinvestigating residential property and contents insurance coverage post-quakes. There have been fundamental changes in contract design and wording in the residential property insurance market. For residential property and contents the biggest effect and changes in the last five years is solely attributed to the earthquakes. The industry data for this line of business indicate higher loss ratios[8] in the year's 2010 and2011, computed to be 62.55% and 62.30% respectively, although the ratios are within the acceptable margin, the 2-year ratio figures are slightly above the 5-year ratio which stood at 58.88%. This is far much different from the industry loss ratios in the affected years of 2010 and 2011 which amounts to 68.22% and 111.81% respectively. Insurance underwriters, like the regulators, use the loss ratio as one of the tools with which to gauge company's suitability for coverage. A period with a high loss ratio, say exceeding 100%, means that the ability to pay claims might become increasingly impaired.

In summary, a critical look at Table 3-4 and Figure 3 shows that in general domestic buildings and contents insurance coverage in New Zealand post-earthquake has an average loss ratio equal to 58.88% in the last five years. Comparing this to US property and casualty insurance industry results for the same period, the loss ratio is slightly above 70%.

Hagendorff, Hagendorff, & Keasey (2015) confirm the fact that the insurance industry as a whole in New Zealand was not extremely affected. The sustained growth in gross written premiums, along with continued soft market conditions-characterised by slight premium rate increases and low catastrophe losses after the 2011 quake has since then strengthened this particular business line to unprecedented levels against any possible ruin.

TABLE 5 *Domestic buildings and contents ($ millions) 12 months to september for period 2009-2015*

YEAR-END	2009	2010	2011	2012	2013	2014	2015
Gross Written Premium ($)	840	933	1,052	1,170	1,342	1,477	1,522
Net Written Premium[9] ($)	779	866	905	963	1,082	1,220	1,211
Net Earned Premium[10] ($)	755	840	827	898	1,003	1,169	1,187
Claims Incurred ($)	541	525	515	533	583	610	634
Loss Ratio (%)	71.65%	62.55%	62.30%	59.33%	58.11%	52.15%	53.43%

Source: (Insurance Council of New Zealand 2016)

In the end what these figures do show us is that New Zealand has been a relatively good market for insurance with a loss ratio below100% and that has encouraged reinsurers to stay in New Zealand following the Christchurch earthquakes.

FIGURE 4 *Gross written premium and claims incurred (Industry domestic buildings and contents insurance in new zealand)*

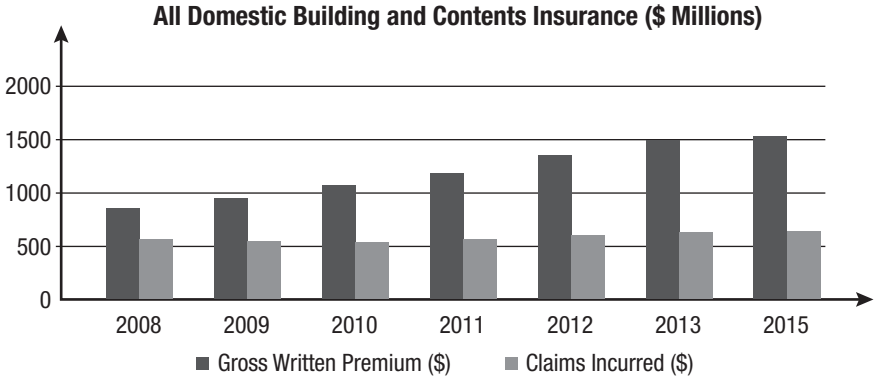


Figure 4 depicts the overall situation in the industry, showing the total claims incurred in the last 7 years versus the gross written premium for the same period for domestic cover. A general look at Figure 4 depicts New Zealand insurance as a hard[11] insurance market place for insurers in this line of business. However, it is totally remarkable that there is no spike at all in claims around the earthquakes (that is, in 2011, above all).This can be explained by the fact that the majority of the claims were either dealt with by EQC or Christchurch business constituted a small proportion of the line when looked at nation level. A further look to the financial reports of the two big brands in the New Zealand insurance industry (IAG and Suncorp), points to the fact that in the aftermath of the quakes underwriters have taken-out more reinsurance arrangements than before. They had taken a view that, it is perhaps more risky hence have bought as much cover as they can get. The private insurance companies under the Insurance Prudential Supervision Act are required to buy a certain quantum of reinsurance. The study confirms that the biggest insurance groups have gone further to strengthen their future financial position. For example, IAGincreased its reinsurance protection for New Zealand to reinsurance pay-outs of NZ$7 billion for a single big quake within the 2015 year. It was also protected with NZ$6.75 billion for a second large seismic event in the same year. This is a 75% increase in reinsurance compared to 2011 reinsurance figures which stood at NZ$4 billion (IAG, 2015).

According to the ICNZ data and the insurer's new policy wording, there has been a fundamental and permanent shift in the insurance market as a result of the earthquakes. In particular, lesser availability of insurance for high risk properties, an increase in the cost of insurance premiums, some insurers having changed how deductibles are calculated, moving from a percent of claim value, to a percentage of insured value and with the residential policy changes from full replacement to sum insured (Sands, Filion, & Skidmore, 2015). The onus now goes on homeowners to determine what their house will cost to rebuild. This came along to help better define risks for insurers; reinsurers likewise can now better understand their maximum liability for residential properties. The increased premiums are understandable given that most of insurers are keen to work together across the industry in an effort to reduce their risk exposure and spur a sharp increase in demand for insurance. In addition, the study finds that some insurers are moving towards specific site risk assessments to improve the accuracy of their underwriting process. Further to all these efforts, insurers now consider factors such as region (physical hazard risk), age of building, construction and height of building and land status which are similar risk factor as proposed in (Freudenburg, 1988).

Insurers now approach the market more cautiously and have learnt the important lesson to treat each risk independently. To demonstrate the challenges faced by some insurance companies with considerable presence in the Christchurch residential property insurance market, this study goes further to investigate the catastrophe effect on a specific business line for an individual insurance company (Table 6).

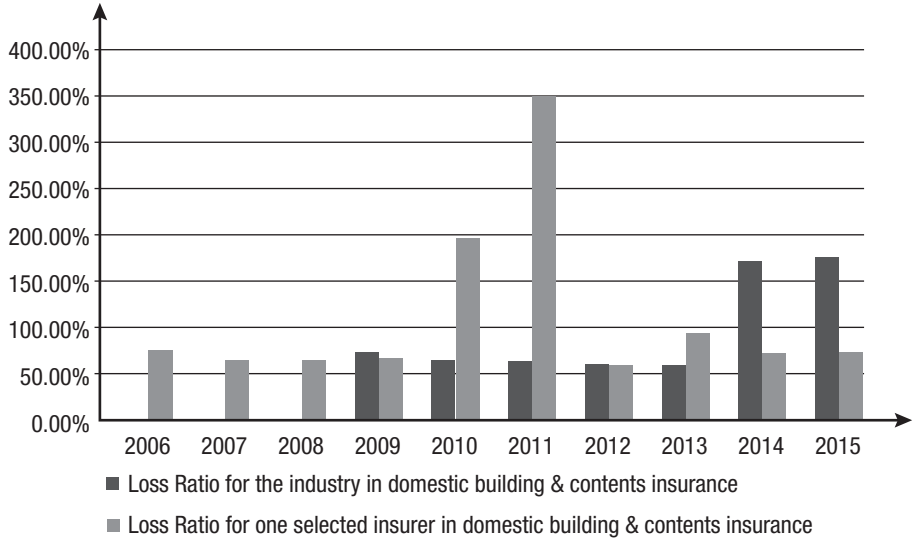
TABLE 6 *Domestic buildings and contents 12 months to June for period 2006-2014*

	JUL-DEC 2006	JAN-DEC 2007	JAN-DEC 2008	JAN-DEC 2009	JAN-DEC 2010	JAN-DEC 2011	JAN-DEC 2012	JAN-DEC 2013	JAN-JUN 2014
Gross Written Premium ($,000)	20,100	45,600	51,600	56,900	63,000	77,500	84,700	89,600	50,000
Net Written Units	86,600	171,200	178,500	184,100	193,300	193,200	184,600	194,700	102,400
Claims Incurred Total ($,000)	15,010	33,380	36,460	36,960	123,370	269,440	48,640	83,080	27,400
Number of Claims	13,160	27,090	26,270	24,230	27,270	29,930	22,500	22,620	12,520
Loss Ratio	74.68%	73.20%	70.66%	64.96%	195.83%	347.66%	57.43%	92.72%	54.80%

Source: Undisclosed Private insurance Company in New Zealand

With this analysis, it is shown that the implication of the earthquake on individual underwriter level in a magnitude of the cost on a scale that cannot be seen from the industry aggregated data. Table 6 together with Figure 5 points out the sharp spike in claims and loss ratio in 2010-2011. This company's claims are different from the average industry claim: which can be attributed to the large concentration of business in Canterbury region. The data used in this analysis is sourced from a selected private insurance company involved in Christchurch residential insurance earthquake claims who agreed to share their data. We spent nearly one year negotiating with various local underwriters to release to us some business statistics for the purposes of this analysis. The local insurance companies proved to be very conservative and reluctant to work with academic studies, and getting larger data set for more rigorous exploratory was an impossible task. The study was only able to source statistics from one undisclosed insurance company for the periods 2006 to 2014. Although these statistics are not sufficient for the study to form some trends in the insurance business cycle, it proves to be useful in illustration of the impact of the two quakes from an individual insurer perspective.

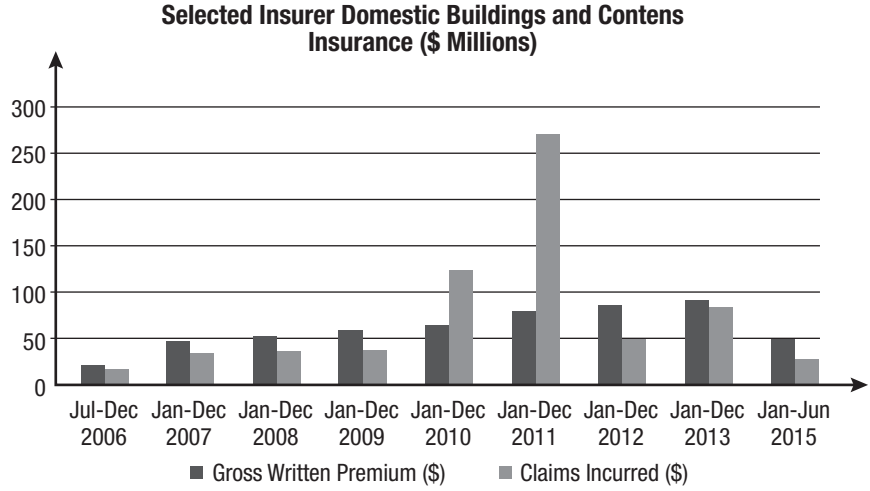
FIGURE 5 *Comparison between one selected insurer and the industry loss ratio*



It is rather straightforward to identify the business implications of the quakes from the loss ratio percentages on Figure 5. In 2010 and 2011 the company registered loss ratios of 195.83% and 347.66% respectively. As mentioned earlier the loss ratio may not necessary

imply that insurance inadvertently made losses, however, the magnitude of the ratio should communicate the claims experience of the insurance company. Therefore if the two ratios do not in totality mean the underwriters made losses in this line of business in the wake of the quakes, it is indicative of the challenges faced by the underwriters in settlement of claims especially those associated with the devastating February 22, 2011 earthquake. In most cases the study reiterates the purpose of a loss ratio is to tell whether, and by how much, claims costs are rising or falling. In this instance therefore the ratios show how devastating the two earthquakes hit the underwriters with high proportions of business in Christchurch. However, the ratio figures are more meaningful when looked at over a decade rather than year on year to understand various changes and derive some trend.

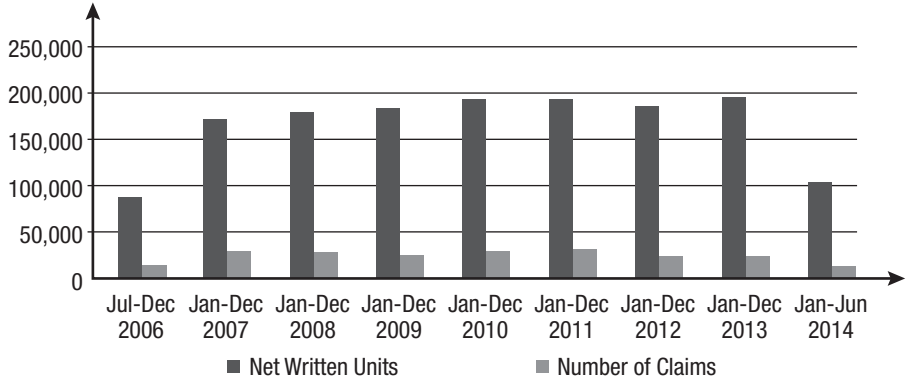
FIGURE 6 *Gross written premium and claims incurred (A selected insurer domestic buildings and contents insurance in New Zealand)*



A plot of loss ratio of a selected alongside that of the entire industry in insurer for the periods June 2006 to June 2014 is presented in Figure 5. The study finds that the two loss ratios for the 2010 and 2011 to be very high when compared to the average loss ratio for the 9 years, with that from 2011 being almost 250% above the 100% the maximum equal proportionality of incurred claims versus earned premium. In such a scenario, the insurance company begins to worry about its ability to meet all the insured clams once they fall due. In most cases however, insurers find themselves fully protected either by digging into catastrophe reserves or claims apportioning to reinsurance

companies. The same conclusions can be made looking at the gross written premium and claims incurred for the selected insurer Domestic Buildings and Contents Insurance.

FIGURE 7 *Net written units and number of claims incurred (A selected insurer domestic buildings and contents insurance in New Zealand)*



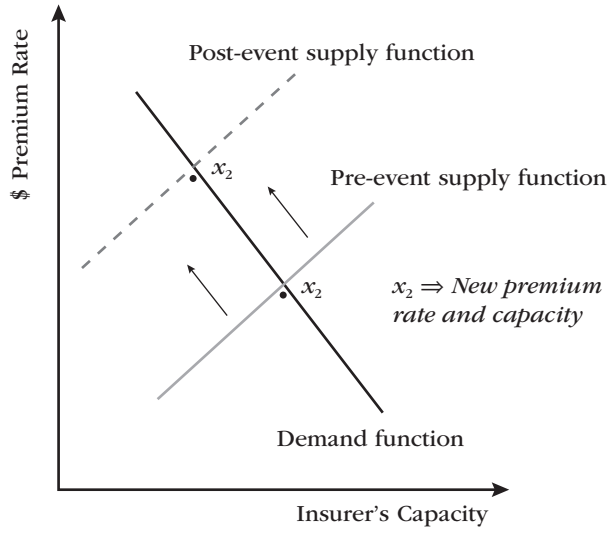
The proportion of properties on claims against the total net written units is presented in Figure 7. This shows that the number of claims filed in 2010-2011 was quite small compared to the total business of the company in this line of business. This demonstrates that it is the magnituted of the damage for those properties that is of importance.

4.3 Further Observations on the Market Reaction Post-Christchurch Earthquakes in Line to the Prior Literature

4.3.1 Supply Shift and Demand Effect After Catastrophe

Following the Christchurch catastrophe, there are number of changes that have occurred in the insurance market. This alludes to the fact that post-disaster insurance market changes are not exceptional within the insurance market context. It is globally observed that a unique type of market adjustment effect occurs when a major disaster spends significant portions of insurer's and reinsurer's capacity[12].

FIGURE 8 *Supply shift and demand effect after catastrophe*



All these market adjustment effects essentially reflect supply constraints which result in higher contract pricing shifting the supply-demand equilibrium to new level as seen in Figure 8. Such adjustments are widely recognized by insurers and reinsurers alike, and reflect market recovery efforts. A number of literatures (P. H. Born & Klimaszewski-Blettner, 2013; Browne & Hoyt, 2000; Poontirakul, 2015) suggests in the insurance industry post large catastrophe exposure, low premium rates are considered sub-optimal. However, looking at the demand-side, individuals and businesses indicate that it is uneconomic to maintain full-insurance coverage at such increased premiums, despite the potential higher risk. In such a scenario, property and business owners carefully re-assess their risk management strategies in handling risks before deciding to approach an insurer.

Based on the individual insurance data and ICNZ all industry data and financial reports, this study finds that there has been a fundamental shift in the insurance market as a result of the 2010-2011 earthquakes. In particular, lesser availability of insurance for high risk properties, an increase in the cost of insurance premiums, deductibles changing from a percentage of the claim to a percentage of the insured value and a shift from full replacement to sum insured.

4.3.2 Fundamental change from full replacement cost to sum insured insurance coverage

Until June 2012, the New Zealand insurance industry provided a residential property insurance policy that covered properties for the cost of full replacement. This meant an insurer would pay to rebuild the insured property without any upper limit. These policies previously used the size of the property in square meters as the basis for the cover. In the aftermath of the quakes, the way industry insures properties changed to sum insured. Instead of being insured for an unspecified replacement cost, now residential properties are insured for up to a maximum specified amount. This means cover will still be offered for the costs of rebuilding the property, but there is a maximum amount of liability payable, even if the actual cost of rebuilding turns out to be greater than that. The move was spurred by a number of reinsurers, the companies who cover insurance companies against natural disasters and catastrophes, requiring residential properties in New Zealand to be insured for a specified amount. This is because after reinsurers reassessed their view of New Zealand risk changed, they realised that the risk is greater than they previously thought and wanted to know the maximum amount that insurers would have to pay to rebuild the residential properties they insure.

In a sum insured environment, customers work out how much it costs to replace their property upfront, before the event. This is a much more effective way of doing insurance business, from insurer's perspective. Under the new environment, suppose there is another similar Christchurch situation, the industry is in a position to be much quicker in terms of settling claims, particularly for policyholders that want to take cash settlement. This change also allows the introduction of partial cover (e.g. 75% insure, 25% self-insure) for those that want to reduce the risk but are willing and able to take on a small amount of it.

5. Conclusions

This paper has argued that without government participation, the private insurance markets can collapse because of some correlated catastrophic event. This is in line with Aseervatham, Born, Lohmaier & Richter (2014), who argue that supply distortions in the aftermath of unprecedented catastrophes are driven primarily by correlated losses. To this effect, many developed and developing countries have implemented some sort of disaster insurance program based on their own unique disaster risk experience. More importantly, the study illustrates the crucial role played by the State in the natural disaster insurance market.

While plans are in place for such state-sponsored systems to kick-in in the occurrence of a particularly severe disaster or series of disasters, the severity of disasters have highlighted existing deficiencies in private insurance coverage and the cost of disaster insurance, either in terms of the premiums paid by policyholders or the structural efficiency of some of the state-sponsored systems.

Based on the individual insurance data and ICNZ all industry data and financial reports, this study finds that there has been a fundamental shift in the insurance market as a result of the 2010-2011 earthquakes. In particular, lesser availability of insurance for high risk properties, an increase in the cost of insurance premiums, deductibles changing from a percentage of the claim to a percentage of the insured value and a shift from full replacement to sum insured. Illustrated herein is the dual insurance system and how it has enabled the private insurers to previously provide residential property and contents insurance cover to over 90% of homeowners in Christchurch. The main criticism of the dual system we gather from the survey of demand-side is centered on its systematic inefficiency in the claims handling process. In comparison to other state-sponsored systems worldwide, the study finds that the EQC's low levies have previously allowed private insurers to offer in New Zealand what could not be realistically offered by other insurers in any other market.

The analysis finds that New Zealand insurance contributes a miniscule 0.67% of premiums to the global insurance underwriting pool and yet recently necessitated one of the top 10 global insurance payouts in the last four decades as mentioned in SwissRE (2012). With this risk premium disproportionality the global reinsurers have been forced to look very closely at their exposure to the New Zealand market. This necessitated the change in the manner into which contract cover is designed; from open-ended full-replacement contract to predetermined sum insured contract that specifically defines the liability undertaken by both insurance and reinsurance market. In general the study finds an average loss ratio equal to 58.88% for domestic buildings and contents insurance coverage in New Zealand post-earthquake. Comparing this to US property & casualty insurance industry results for the same period, the loss ratio is slightly above 70% (Hagendorff et al., 2015). What this figure does show us is that New Zealand has been a relatively good market for insurance with loss ratio below 100% and that has encouraged reinsurers to stay in the market following the Christchurch earthquakes. To this effect, the supply of insurance contracts in New Zealand had not been marginally affected by the quakes.

This study postulates that in general premium increases after catastrophic events are driven by both risk capital reduction and the fact that insurance companies update the assumed risk exposure of the affected areas. If they anticipate that a certain region will be affected more frequently or more severely in the future then the premium can be set at a higher rate. Froot & O'Connell (1999) disentangle both effects by analysing reinsurance prices in the aftermath of different types of natural catastrophes. Since they also observe price increases outside of the affected area independent of the actual exposure to a certain hazard, they conclude that capital market imperfections (a shortage of capital) are the main reason for the price increases. This paper does not consider the effect of capital market on insurance market underwriting capacity.

Reference

Aon/Benfield. (2013). Reinsurance Market Outlook. Reinsurance Capacity Growth Continues to Outpace Demand. http://thoughtleadership.aonbenfield.com/Documents/20130103_reinsurance_market_outlook_external.pdf.

Aseervatham, V., Born, P., Lohmaier, D., & Richter, A. (2014). Putting Everything under the Same Umbrella–Hazard-Specific Supply Reactions in the Aftermath of Natural Disasters.

Aseervatham, V., Born, P., Lohmaier, D., & Richter, A. (2015). Putting everything under the same umbrella–Hazard-specific supply reactions in the aftermath of natural disasters. *Munich Risk and Insurance Center Working Paper*(25).

Atreya, A., Ferreira, S., & Michel-Kerjan, E. (2014). What Drives Households to Buy Flood Insurance? Evidence from Georgia.

Bommer, J., Spence, R., Erdik, M., Tabuchi, S., Aydinoglu, N., Booth, E., … Peterken, O. (2002). Development of an earthquake loss model for Turkish catastrophe insurance. *Journal of Seismology, 6*(3), 431-446.

Born, P., & Viscusi, W. K. (2006). The catastrophic effects of natural disasters on insurance markets. *Journal of Risk and Uncertainty, 33*(1-2), 55-72.

Born, P. H., & Klimaszewski-Blettner, B. (2013). Should I Stay or Should I Go? The Impact of Natural Disasters and Regulation on U.S. Property Insurers' Supply Decisions. *Journal of Risk & Insurance, 80*(1), 1-36. doi:10.1111/j.1539-6975.2012.01477.x

Brookie, R. (2014). 20. Governing the Canterbury Earthquake Recovery, 2010–2011: The debate over institutional design. *Future-Proofing the State*, 251.

Brown, C., Seville, E., & Vargo, J. (2013). *The role of insurance in organisational recovery following the 2010 and 2011 Canterbury earthquakes*. Retrieved from

Browne, M. J., & Hoyt, R. E. (2000). The demand for flood insurance: empirical evidence. *Journal of Risk and Uncertainty, 20*(3), 291-306.

Buchanan, A., Carradine, D., Beattie, G., & Morris, H. (2011). Performance of houses during the Christchurch earthquake of 22 February 2011. *Bulletin of the New Zealand Society for Earthquake Engineering, 44*(4), 342-357.

Bull, D. (2013). Earthquakes and the effects on structures: Some of the lessons learnt. *Australian Journal of Structural Engineering, 14*(2), 145-165.

Cagle, J. A., & Harrington, S. E. (1995). Insurance supply with capacity constraints and endogenous insolvency risk. *Journal of Risk and Uncertainty, 11*(3), 219-232.

CEBR. (2012). Global Underinsurance Report. *The Society of Lloyd's*.

Cooper, W. H., Donnelly, J. M., & Johnson, R. (2011). Japan's 2011 earthquake and tsunami: economic effects and implications for the United States. *Analysis*.

Cummins, D., Lewis, C., & Phillips, R. (1999). Pricing excess-of-loss reinsurance contracts against cat as trophic loss *The financing of catastrophe risk* (pp. 93-148): University of Chicago Press.

Dacy, D. C., & Kunreuther, H. (1969). economics of natural disasters; implications for Federal policy.

Franco, G. (2014). Earthquake mitigation strategies through insurance. *Encyclopedia of Earthquake Engineering". Edited by Beer, M., Kougioumtzoglou, IA, Patelli, E. and Siu-Kui Au, I.*

Freudenburg, W. R. (1988). Perceived risk, real risk: Social science and the art of probabilistic risk assessment. *Science(Washington), 242*(4875), 44-49.

Froot, K. A., & O'Connell, P. G. (1999). The pricing of US catastrophe reinsurance *The Financing of Catastrophe Risk* (pp. 195-232): University of Chicago Press.

Grace, M. F., & Klein, R. W. (2003). Homeowners Insurance: Market Trends, Issues and Problems. *Issues and Problems (August 28, 2003)*.

Grace, M. F., & Klein, R. W. (2009). The perfect storm: hurricanes, insurance, and regulation. *Risk Management and Insurance Review, 12*(1), 81-124.

Grace, M. F., Klein, R. W., Kleindorfer, P. R., & Murray, M. (2003). Catastrophe Insurance: Supply, Demand and Regulation.

Grace, M. F., Klein, R. W., & Liu, Z. (2005). Increased hurricane risk and insurance market responses. *Journal of Insurance Regulation, 24*(2), 3.

Gron, A. (1994). Capacity constraints and cycles in property-casualty insurance markets. *The RAND Journal of Economics*, 110-127.

Grossi, P., Kunreuther, H., & Patel, C. C. (2005). *Catastrophe Modeling: A New Approach to Managing Risk*: Springer.

Hagendorff, B., Hagendorff, J., & Keasey, K. (2015). The Impact of Mega-Catastrophes on Insurers: An Exposure-Based Analysis of the US Homeowners' Insurance Market. *Risk Analysis, 35*(1), 157-173.

Harrington, S. E., Niehaus, G., & Yu, T. (2013). Insurance price volatility and underwriting cycles *Handbook of Insurance* (pp. 647-667): Springer.

IAG. (2015). Annual Report Final 2015. http://www.iag.com.au/results-and-reports/FY2015/pdf/2015-IAG-annual-report-final.pdf.

Kachali, H., Whitman, Z., Stevenson, J., Vargo, J., Seville, E., & Wilson, T. (2015). Industry sector recovery following the Canterbury earthquakes. *International Journal of Disaster Risk Reduction, 12*, 42-52.

King, A., Middleton, D., Brown, C., Johnston, D., & Johal, S. (2014). Insurance: Its role in recovery from the 2010-2011 Canterbury earthquake sequence. *Earthquake Spectra, 30*(1), 475-491.

Klein, R. W., & Kleindorfer, P. R. (1999). *The Supply of Catastrophe Insurance Under Regulatory Constraints*. Paper presented at the project meeting of NBER on Insurance on.

Kousky, C. (2010). Understanding the demand for flood insurance. *Natural Hazards Review, 12*(2), 96-110.

Marquis, F., Kim, J. J., Elwood, K. J., & Chang, S. E. (2015). Understanding post-earthquake decisions on multi-storey concrete buildings in Christchurch, New Zealand. *Bulletin of Earthquake Engineering*, 1-28.

Merkin, R. (2012). Christchurch Earthquakes Insurance and Reinsurance Issues, The. *Canterbury L. Rev., 18*, 119.

Michel-Kerjan, E. O., & Kousky, C. (2010). Come rain or shine: Evidence on flood insurance purchases in Florida. *Journal of Risk and Insurance, 77*(2), 369-397.

Nguyen, T. (2013). Insurability of Catastrophe Risks and Government Participation in Insurance Solutions. *Geneva, Switzerland: UNISDR*.

Parker, M., & Steenkamp, D. (2012). The economic impact of the Canterbury earthquakes. *Reserve Bank of New Zealand Bulletin, 75*(3), 13-25.

Pierepiekarz, M. R., Johnston, D., Berryman, K., Hare, J., Gomberg, J., Williams, R., & Weaver, C. S. (2014). LESSONS FROM THE 2010-2011 EARTHQUAKE SEQUENCE IN CANTERBURY, NEW ZEALAND.

Poontirakul, P. (2015). The role of insurance in business recovery after a natural disaster: The case of the 2011 Christchurch earthquake.

Potter, S., Becker, J., Johnston, D., & Rossiter, K. (2015). An overview of the impacts of the 2010-2011 Canterbury earthquakes. *International Journal of Disaster Risk Reduction, 14*, 6-14.

Ragin, M. A., & Halek, M. (2015). Market Expectations Following Catastrophes: An Examination of Insurance Broker Returns. *Journal of Risk and Insurance*.

Sands, G., Filion, P., & Skidmore, M. (2015). *Cities at Risk: Planning for and Recovering from Natural Disasters*: Ashgate Publishing, Ltd.

Swiss-Re. (2012). Natural catastrophes and man-made disasters in 2011: historic losses surface from record earthquakes and floods. sigma No 2/2012: Zurich.

SwissRE. (2012). Natural catastrophes and man-made disasters in 2011: historic losses surface from record earthquakes and floods. sigma No 2/2012: Zurich.

Tsubokawa, H. (2004). Japan's Earthquake Insurance System. 日本地震工学会論文集, *4*(3), 154-160.

Winter, R. A. (1994). The dynamics of competitive insurance markets. *Journal of Financial Intermediation, 3*(4), 379-415.

Wu, T. Y., Cheung, J., Cole, D., & Fink, J. N. (2014). The Christchurch earthquake stroke incidence study. *Journal of Clinical Neuroscience, 21*(3), 412-415.

NOTES

1. **Corresponding author:** Researcher at Department of Economics and Finance at University of Canterbury and Lecturer in Actuarial Science at Dedan Kimathi University of Technology. For comments, please email: richard.mumo@pg.canterbury.ac.nz Alternative emails: richard.mumo@dkut.ac.ke

2. Professor of Economics and Finance at University of Canterbury

3. The "red-zone" comprises the land in Christchurch, occupied as residential pre-earthquakes, that was purchased by the Government after having been declared uninhabitable post-earthquakes.

4. This is an add-on to the primary policy, which offers benefits over and above the policy subject to certain conditions.

5. Goods and services tax.

6. Lead Reinsurer is the reinsurer responsible for negotiating the terms and rates of are insurance treaty that other reinsurers participate in.

7. Total premium (direct and assumed) written by an insurer before the deductions for reinsurance and ceding commissions. It may include additional and/or return premiums. Gross written premium is calculated as the actual premium less all premium refunds and rebates

8. Proportionate relationship of incurred losses to earned premiums expressed as a percentage.

9. Net written premium is gross written premium less outward treaty and facultative reinsurance premium.

10. Amount of total premiums collected by an insurance company over a period that have been earned based on the ratio of the time passed on the policies to their effective period. Net earned premium is net written premium plus unearned net premium at beginning of quarter less unearned net premium at end of quarter. Gross earned premium is gross written premium plus unearned gross premium at beginning of quarter less unearned gross premium at end of quarter.

11. key characteristics of hard market include; higher insurance premiums, more stringent underwriting criteria-underwriting is more difficult, reduced capacity-insurance write less insurance policies and less competition among insurance carriers.

12. This is the principal amount of insurance or reinsurance available from a company or the market in general. Capacity is determined by financial strength and is also used to refer to the additional amount of business that a company or the total market could write based on excess (unused) capital.