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Impact of Natural Disasters on Production Networks and Urbanization in New Zealand

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Abstract: *New Zealand's history of natural disasters and its vulnerability to various types of disaster are outlined briefly. A summary description of the country's arrangements for preparing for natural disasters and managing the response to, and recovery from, them is provided.*

The series of earthquakes that affected Christchurch, New Zealand's second largest city, between September 2010 and early 2012 is considered as a case study. The direct and indirect tangible costs of the events are estimated as $NZ 30.9 billion (approximately $US24.5billion), or 15.8% of the country's GDP, on a replacement cost basis. Approximately 78% of this cost will be covered by insurance. On a depreciated replacement cost basis the damage is estimated at $NZ18.7 billion.

The significant effects of the events on the population, labor market, reported crime, urbanization and location of businesses and production of the region are also described.

The case study suggests that New Zealand's arrangements for natural disasters worked well in most regards. The case study also highlights the advantage of international co-operation in the response to natural disasters. It also suggests that while high rates and levels of disaster insurance ameliorate the financial impact, they can complicate achieving effective recovery. This is because insurance funds increase the alternatives available to the affected population and investors in respect of reinvestment and rebuilding the damaged region. The lag before insurers will accept new risks can also create delays and impede the momentum to recovery.

The final section of the paper draws from New Zealand's recent disaster experience in Christchurch to present some policy recommendations relevant to New Zealand and the East Asia region.

Keywords*:* Natural disasters, Monitoring, rescue, Recovery, Earthquakes, New Zealand, Christchurch earthquakes, Economic impact, Costs, Disaster insurance, East Asian regional co-operation

JEL classification: Q54, Q52, G22,F42, O56

1. Introduction

1.1. Geography

New Zealand is a string of islands situated in the South West Pacific Ocean approximately 1,600 kilometers east of mainland Australia[1] and approximately 1,000 kilometers south of New Caledonia, Fiji and Tonga. The distance between the northernmost point of New Zealand (Nugent Island) and its southernmost point (Jacquemart Island) is 2,813 kilometers. The islands making up the country lie in a northwest-southeast direction between latitudes 29^{o} and 53^{o} South on the boundary of the Pacific and Indo-Australian continental plates.

The edges of the Pacific plate define most of the 'Ring of Fire'. This is the active volcanic and seismic area that encircles the Pacific Ocean and includes Japan, the Aleutian Island chain, the southern coast of Alaska, and the west coast of North America (California).

Virtually all of New Zealand's 4.4 million population lives on the two major islands – the North and South Islands. These are situated very close to one another near the center of the string of islands that make up the entire territory. The Pacific and Indo-Australian plates meet under the South Island and under and close to the southeast coast of the North Island.

1.2. Vulnerability to Natural Disasters

1.2.1. Geophysical Hazards

In the region of New Zealand, the Pacific plate is currently moving slowly westward and sliding under the Indo-Australian plate. The result is that New Zealand experiences frequent earthquakes, often of significant magnitude, and contains several active volcanic and geothermal areas. The outlying islands are all volcanic in origin; some of them, like Raoul Island and White Island, are very active but others are dormant or extinct.

The major city, Auckland, with a population of 1.5 million, is spread across a field of 49 dormant volcanoes. All have erupted during the last 250,000 years; the most recent and largest eruption was approximately 600 years ago, after inhabitation

of the area by humans. The very violent last eruption produced the same amount of lava as the eruptions that created the rest of the volcanic field.[2]

On 10 June 1886 the volcanic Mt Tarawera, south-east of Rotorua in the central North Island, erupted. It killed an estimated 120 people, caused a major rift in the landscape and submerged a natural wonder, the Pink and White Terraces, into Lake Tarawera.[3]

The capital city, Wellington, with a population of 0.35 million, lies directly above the boundary of the Pacific and Indo-Australian plates. As a result, it has three major fault-lines in close proximity to it: the Ohariu, Wairarapa, and Wellington Faults.[4] There are frequent movements on these faults and since 1855 there have been three significant events generating earthquakes with magnitudes between 7.2 and 8.2 on the Richter scale (Table 1).[5]

Christchurch, which until recently was thought to be most vulnerable to a tsunami and not significantly at risk from earthquakes, experienced four major and approximately 11,000 other earthquakes in the 21 months after 4 September 2010. The largest quake, with a magnitude of 7.1, struck on 4 September 2010. Its epicenter was approximately 40 kilometers west of the city center near the small country town of Darfield. It caused significant property damage in the city but no loss of life. The most destructive, with a magnitude of 6.3, struck on 22 February 2011. Its epicenter was directly under the city. It caused very significant damage to most buildings in the Central Business District (CBD) and significant destruction to many housing areas in the suburbs, especially in the south and east of the city. The death toll was 185 with 134 of the deaths occurring in the collapses of just two relatively modern buildings in the CBD.[6]

Table 1: New Zealand Earthquakes with Fatalities, 1855-2011

Date	Location	Richter scale / Modified Mercalli Scale	Impact	Number killed
23 Jan 1855	Wairarapa (Wellington)	8.2 X (Intense)	Destroyed large proportion of buildings. Radically altered landscape in Wellington region	5 - 9
17 June 1929	Murchison (West Coast)	7.8 IX (Violent)	Caused massive landslides. Destroyed many buildings	17
3 Feb 1931	Hawkes Bay (Napier)	7.8 X (Intense)	Destroyed most buildings in Napier. Raised landscape.	256
24 May 1968	Inangahua (West Coast)	7.1 X (Intense)	Destroyed most buildings. Caused massive landslides.	6
22 Feb 2011	Christchurch	6.3 X (Intense)	Very extensive property damage. Liquefaction of low lying areas. Caused landslips on hills.	185

Note: The Modified Mercalli Scale is a 12 point scale of the destructiveness of an earthquake. The scale is expressed in Roman numerals. An earthquake graded I is the least destructive. The most destructive is graded XII. The ratings given are for the destructiveness of the fatal earthquakes in this table relate to the destructiveness at the epicentre of each earthquake.

Sources: New Zealand History online (n.d.) a. and Mcsaveney (2012).

New Zealand has experienced approximately ten tsunami with waves higher than 5 meters since 1840. The four major cities are all located close to the sea and contain areas vulnerable to inundation by tsunami. Christchurch has the largest area and most vulnerable population. Most tsunami that have impacted on New Zealand recently have been generated by distant events on the Ring of Fire, for which there have been ample and effective warnings. There is potential, however, for tsunami to be generated by many numerous local sources. There could be very little or no effective warning of these events.[7]

1.2.2. Biological Hazards

The major islands of New Zealand have been submerged below sea-level at various points in their geological history as a result of the movements relative to one

another of the tectonic plates beneath the country. The consequence of this, and the relative isolation of the country, is that much of New Zealand's flora and fauna are unique and many plant and animal diseases found elsewhere in the world are not present in New Zealand.

The economy is heavily dependent on agricultural production, forestry and fishing and the processing of the products of these industries. As a result, the economy is almost uniquely vulnerable to introduced insect, animal and plant species and diseases.

There have been several introductions of economically significant biological hazards in recent years:

- painted apple moths – a serious apple and pear tree pest from Australia – were discovered in Glendene, Auckland in May 1999, but had been eradicated by March 2006;[8]
- gypsy moth – a serious tree pest - was discovered in Hamilton in March 2003, but an eradication programme was successful;[9]
- varroa bee mites – a parasite that targets honey bees – was discovered in the North Island in 2000. An attempt to eradicate the organism was unsuccessful and by 2006 it had spread throughout the North Island and much of the South Island;[10]
- a kiwifruit vine disease, PSA, was discovered in the Bay of Plenty, the major kiwifruit production region, in November 2010.[11] An attempt to confine and eradicate the disease has not been successful.[12]

New Zealand has a modern and effective health system and the last occasion on which an epidemic caused significant mortality was the "Spanish" influenza epidemic in 1918. An estimated 8.600 people died in that event.[13] The "SARS", avian-flu and swine-flu scares in the early years of this century impacted on travel and tourism but had little effect on the economy as a whole. SARS and avian-flu were not introduced into the New Zealand population[14] but a total of 22 deaths were recorded as due to the 2009 outbreak of swine-flu.[15]

1.2.3. Hydrological and Meteorological Hazards

The climate and maritime location of New Zealand can occasionally produce "weather bombs". These involve ultra-high rainfall in localized areas in a short period of time, high winds and, when near the coast, high surf and coastal erosion.[16] The combination of weather bombs and steep terrain can produce flash floods in small streams and rivers, and disasters involving multiple deaths can occur. The two major disasters of this kind were:[17]

- destruction on 19 February 1938 of a railway construction work camp at Kopuawhara on the East Coast killing 21 persons; and
- the deaths on 16 April 2008 of six students and a teacher caught by a flash flood in a stream in Tongariro National Park while undertaking outdoor education.

Weather bombs can also cause extensive erosion or silting of pastureland and have a significant economic effect on farm production at a local level. The impacts can last several years. The East Coast was badly affected this way by Cyclone Bola in March 1988.[18]

For a landslide to damage more than a handful of houses is rare, but not unknown. A suburb in Dunedin, the country's second largest city in the South Island, was the site of a large landslip on 1979. The result was that 70 houses had to be either destroyed or relocated. There were no serious injuries and no loss of life.[19] On 7 May 1846 a massive landslide destroyed a settlement on the shores of Lake Taupo in the central North Island, killing around 60 people.[20]

New Zealand is not, however, vulnerable to any significant extent to tornadoes and hurricanes. Nor is it as vulnerable to widespread and multi-year droughts as are parts of Australia. Drought can materially impact agricultural production in some areas, but its bigger potential threat to the economy is through its impact on electricity supply.

2. Natural Disaster Risk Management

2.1. Monitoring

New Zealand has a comprehensive natural hazards monitoring regime.

2.1.1. Geophysical Hazards

All the active volcanoes in the country are monitored by GeoNet, a service of the Institute of Geological and Nuclear Sciences (GNS), a Crown Research Institute. A variety of techniques are used: high resolution GPS instruments to detect deformation of the volcano's shape; seismographs to detect movements in magma; and gas and water sampling to detect changes in chemical composition.[21] The Crater Lake on Mt Ruapehu is monitored, also by GeoNet, in order to provide warnings of lahar (volcanic mud) floods in the streams and rivers below the mountain.[22] The Auckland volcanic field is monitored by the regional government using in-ground and surface seismographs to detect signs of magma build up below the earth's surface.[23]

GeoNet provides a country-wide network of seismic stations that transmit their data to the GeoNet Data Management Centre where it is analyzed by automated processes. If the automated processes detect an earthquake of material strength, the Duty Response Team is notified and if the Duty Officer confirms that the earthquake is real and significant, the earthquake information is released.[24]

New Zealand is linked to the Pacific Ocean tsunami warning system which is based in Hawaii. It also has a network of 17 gauge stations around the coastline and on the outlying Kermedec and Chatham Islands. The network is operated by GNS as part of GeoNet[25] in conjunction with Land Information New Zealand and the National Institute of Water and Atmospheric Research (NIWA).[26]

2.1.2. Biological Hazards

The Biosecurity division of the Ministry for Primary Industries is responsible for preventing biological hazards from entering the country. It ensures passengers' baggage, postal and courier packages and aircraft and ship cargoes arriving in the country are inspected to detect biological hazards at the border. Virtually all

baggage and parcels are scanned by electronic equipment able to detect biological material. Specially trained sniffer dogs are also used extensively.

Cargo with a moderate to high risk of containing biological material is identified from manifests on the basis of their source and the sending party. The identified risky items are inspected. Pheromone traps are located around airports and ports to attract unwanted insect species to check whether there has been an invasion. If an invasion is detected the Biosecurity division is responsible for deciding whether to attempt to eradicate the new organisms, and to organize the effort if it does.

The Ministry of Health has responsibility for border health protection measures. It is only active at points of entry when there is a perceived risk. It has two major operating documents: the National Health Emergency Plan and the New Zealand Pandemic Influenza Plan. The Epidemic Preparedness Act 2006 provides the legislative basis for the Ministry to respond in the event of an emergency.

2.1.3. Hydrological and Meteorological Hazards

The Meteorological Service of New Zealand Ltd (MetService),[27] a State-owned Enterprise, undertakes short- and medium-term weather forecasting, including forecasting extreme weather events such as weather bombs, tornado strikes, lightning, and sea surges. There are also a number of private sector providers of short- and medium-term weather forecasts that compete with MetService.

NIWA, a state-owned research and consultancy company, undertakes long-term weather forecasts. It bases these largely on the state of the Southern Oscillation and whether the weather pattern is likely to follow a *La Nina* or *El Nino* pattern in the next few months, or whether it will be in a transition phase between these states.[28]

GeoNet monitors areas with significant potential for damaging and life-threatening landslips.[29]

Transpower New Zealand Ltd, the state-owned enterprise that operates the national electricity grid, produces hydrological risk curves which show the probability that the electricity system will exhaust the supply of water for hydro-generation, given current lake levels. It forecasts demand and production from non-hydro-generation plant, and takes account of the historical pattern of water inflows over the last 81-years. The lake level and inflow data are acquired by the Electricity Authority from providers such as NIWA and electricity generation companies.

2.2. Warnings

The principal vehicles for warning and informing the public about natural hazards are the public media: radio, television, the internet and print. GeoNet operates a website that is updated in real time with information about the risks it monitors.[30]

There are also some specialized communications channels. GeoNet, for example, provides eruption warnings directly to the aviation industry, and lahar warnings directly to those responsible for bridges and roads that are vulnerable. The hydrological information of relevance for electricity production is communicated to market participants over the system used to trade electricity and by e-mail. It is also published on websites.

Warnings about tsunami generated distant from New Zealand are distributed over the radio and television media. There is currently no system to warn the public about tsunami originating close to New Zealand as it is considered the warning times would be too short to be useful.

2.3. Ex-post Rescue and Recovery

The Ministry of Civil Defence and Emergency Management (CDEM) is responsible for the management of major disasters due to earthquakes, volcanic eruptions, tsunami, floods and landslides. It does this by coordinating the capabilities of other emergency management organizations, such as the fire service, ambulance service, urban search and rescue (USAR), search and rescue (SAR), police, local authorities, gas, water, electricity and telecommunications utility operators, the military and local civil defense officials and volunteers.[31] CDEM has very wide powers to require co-operation in the provision of support and compliance with its instructions during a declared civil defense emergency.

In a very major natural disaster, CDEM will call on international support when the size of the task is beyond New Zealand's internal capacity to respond. For example, in the rescue phase following the 22 February 2011 Christchurch earthquake, USAR teams from Australia, Japan, China, Singapore, Taiwan, the United Kingdom and the United States, in addition to New Zealand's USAR team,

searched for injured persons and bodies in the rubble. At the peak there were 600 USAR personnel, most of whom came from outside New Zealand.[32]

CDEM also used 330 police from four Australian States and the Australian Federal Police to assist New Zealand police.[33] The New Zealand military and 116 members of the Singapore Armed Forces provided transport support and manned cordons around the most damaged areas.[34] In the recovery phase, victim identification experts from Thailand, the United Kingdom, Israel, Australia and Taiwan were used,[35] and engineers from several countries, including Australia, Singapore and Malaysia, have been used to assist in making geotechnical and building assessments.

New Zealand routinely assists other countries that experience major disasters by sending USAR personnel, rural fire fighters (almost routinely to the west coast of the United States and east coast of Australia), and victim identification experts. In recognition of the fact that New Zealand and Australia regularly provide disaster assistance to one another, since early 2012, New Zealand has been a full member of the Australian National Emergency Management Committee.[36] The Committee has effectively become an Australasian body.

In a more limited and local disaster of the kind dealt with by CDEM, the local civil defense organization, which is part of the local government authority of an area, is responsible for management of the emergency and coordinating the capabilities of the other emergency management organizations. It fulfills a role similar to the role of CDEM in more major events.

Biosecurity disaster management is the responsibility of the Biosecurity division of the Ministry for Primary Industries. It generally uses private sector contractors to spray for insects and plant diseases and to kill livestock or remove infected plants. It usually calls on the assistance of the police for enforcing quarantine restrictions around infected areas and properties but in a major disaster would also call upon the military to assist in this manner.

Public health management is the responsibility of the Ministry of Health and it has available to it the public and private health systems, and legal powers to exclude persons from entering the country and requiring people to remain in isolation.

Responsibility for declaring emergencies in the electricity system due to hydrological conditions rests with Transpower New Zealand Ltd. However, the Electricity Authority – the sector regulator – sets the rules under which Transpower must decide whether to do this and how it should operate if it does.

2.4. Ex-post Recovery and Reconstruction

There have been two very major natural disasters in New Zealand in the last 100 years, along with numerous more minor ones. The first was a 7.8 scale earthquake on 3 February 1931. This killed 256 persons and destroyed Napier and much of Hastings in the Hawkes Bay, an area which at the time was home to 5% of the country's population.[37] The capital loss amounted to approximately 2.3% of New Zealand's annual GDP or 45% of the region's annual GDP at the time.[38]

The second was the series of sizeable earthquakes between September 2010 and December 2011 which killed 185 people and destroyed much of Christchurch's CBD and severely damaged some of the surrounding region, an area which at the time was home to approximately 12% of New Zealand's population. The loss at replacement cost in this case is currently estimated to be approximately 15.8% of New Zealand's GDP in 2010/11 and 114% of the region's annual GDP.

On both occasions, the central Government appointed a special body with wide powers to organize and oversee the recovery and reconstruction. In Napier in 1931, the power was placed in the hands of two commissioners – a judge and an engineer.[39] This action has been viewed as very successful. Recovery was relatively swift and successful, especially compared with Hastings, which had suffered less damage, and where the local authority was left to organize recovery. Following the Christchurch earthquakes, the power has been placed by legislation in the hands of a special government body – the Canterbury Earthquake Reconstruction Authority (CERA) – headed by a Cabinet Minister but subject to oversight of its exercise of its special powers by a review panel of highly respected citizens.[40] It is too early to judge whether CERA has been a success or not.

3. Impact of Natural Disasters on Urbanization

3.1. Economic Impacts of Disasters: Case Study

3.1.1. Impact on Christchurch

The sequence of major earthquakes in Christchurch that started in September 2010 provide an instructive case study of the short-term and medium-term economic impacts of a major natural disaster in New Zealand and of the effectiveness of the country's regime for the management of natural disasters. The area directly affected by these earthquakes is home to around 12% of New Zealand's population and includes Christchurch, New Zealand's second largest city after Auckland.

Table 2: Earthquakes in Christchurch Area 4 Sept 2010 – 24 June 2012

Richter scale	Number
Less than 4	10,685
4 to less than 5	380
5 to less than 6	49
6 to less than 7	3
7 and above	1

Source: Crow (update live) (last accessed 25 June 2012).

Each of the four major earthquakes, and many of the smaller quakes, caused some property damage (Table 2). The event on 22 February 2010 caused by far the most damage. By 24 June 2012 orders requiring the total demolition of 798 commercial and industrial buildings and partial demolition of 208 more had been issued by the authorities.[41] A large proportion of the buildings in the CBD, which took the main force of the 22 February 2011 earthquake, have been demolished or are in the process of being demolished. This includes most of the high-rise buildings and a good proportion of the CBD's hotel accommodation capacity, along with several large public buildings, such as the Anglican and Catholic Cathedrals, the Town Hall and the Convention Centre.

Many roads were extensively damaged, and there was major damage to the underground sewage and water pipes. Christchurch does not have a piped gas supply except in small areas in isolated suburbs. The local electricity distribution system

suffered some damage to underground and overhead cables, but greater damage to substations. The national electricity grid suffered only very minor damage.

Very little damage was sustained by plant, machinery and equipment in manufacturing plants and offices. Partly this was because virtually all office buildings and factories remained upright so their contents remained largely intact, despite the structures being damaged in many cases beyond repair. This is what the building codes had been designed to achieve – the preservation of structural form sufficient not to endanger human life and not necessarily the ability to repair the building. It is also partly because manufacturing in Christchurch is concentrated in the west of the city, which was less severely affected.

The public was not allowed into the CBD area for several months after 22 February 2011, not even to recover equipment and personal belongings. As a result, many businesses and local and central government agencies were required to replace their office equipment in order to remain functioning. They have since been able to recover their equipment, stocks and files.

The four most significant quakes caused some injuries but only the events on 4 September 2010 and 22 February 2011 caused serious injuries. Approximately 170 people were seriously injured by the two events.[42] 185 people died as a result of the 22 February 2011 earthquake but there were no fatalities resulting from the other earthquakes.

The four most significant earthquakes all resulted in liquefaction of the ground in many of the lower lying areas close to rivers in the greater Christchurch area. As a result, by the end of June 2012, 6,791 residential properties,[43] or 3.7% of the approximately 185,000 in the area, had been declared as unfit sites on which to rebuild because geo-technical problems with the soils upon which they are built mean it would be uneconomic to do so. These sites are mainly clustered adjacent to the lower reaches of two major rivers. The result will be that several areas of the greater metropolitan area will be abandoned and allowed to return to farmland or be converted to parks and reserves.

The Government has offered to purchase these residential sites at their 2008 market valuation, which it considers to be a good approximation of their market value at the time of the February 2011 earthquake. Approximately 3,000 other

residential sites await final geotechnical assessment, so the total number of residential sites to be abandoned is likely to be between 7,000 and 9,000.

There are also several thousand houses in the city which require very substantial renovation or complete re-building on their existing sites, if they are to be occupied again. Approximately 165,000 residential properties suffered some degree of damage.

3.1.2. Classification of Economic Costs

The World Bank has recently published a suite of studies on the economic and social impact of natural disasters.[44] Most of the papers are empirical studies but one of the more recently published World Bank studies, the *Economics of Natural Disasters: Concepts and Methods* by Stephane Hallegatte and Valentine Przyluski provides a useful classification of the economic costs of a natural disaster.[45]

Hallegatte and Przyluski distinguish direct and indirect losses. The former they define as "the immediate consequences of the disaster physical phenomenon."[46] They further distinguish between direct market losses – losses to goods and services that are traded on markets, and for which a price can be observed - and direct non-market losses – all damage that cannot be repaired or replaced through purchases on a market.[47]

Hallegatte and Przyluski propose two criteria to help identify indirect losses. First, indirect losses are caused by secondary effects, not by the hazard itself. Secondly, costs are indirect if they span a longer period of time, a larger spatial area or a different economic sector than the disaster itself. They note that for capital destroying disasters, the term "indirect losses" is often used as a proxy for "output losses" or the reduction in economic production provoked by the disaster, including the costs of business interruption and the longer term consequences of infrastructure and capital damages. Like direct losses, indirect losses may be market or non-market losses.

Indirect losses can have "negative-costs" components, i.e. gains from additional activity created by the reconstruction. These gains can occur in the affected region or in another region.[48]

Hallegatte and Przyluski note that to implement these definitions of costs it is necessary to define a baseline or counterfactual scenario; the scenario of what would

have occurred in the absence of a disaster. They also note that identifying the relevant costs of a disaster cannot be done independently of the purpose of the assessment. The costs relevant to insurance companies, households, firms and the Government can all differ depending on their purpose.[49]

3.1.3. Cost Estimates

Table 3 sets out estimates of the measurable direct and indirect costs of the earthquakes in the greater Christchurch area. Appendix I provides details of how the estimates have been derived using the data available at the end of June 2012. The estimates are in New Zealand dollars. New Zealand has a floating exchange rate and its value against other currencies, including the United States dollar, moves widely. The daily average exchange rate between the United States dollar and the New Zealand dollar in the calendar year 2011 was $NZ1 = $US0.7916.[50]

For most depreciable assets like buildings, network assets and commercial and industrial plant and equipment two cost estimates are provided: a replacement cost (RC) and a depreciated replacement cost (DRC) estimate. The RC estimates for these assets reflect the cost of replacing those destroyed in the earthquake with equivalent new assets at current market prices. The DRC estimates are the RC estimates adjusted for the estimated extent to which these replaced assets were already depreciated at the time they were destroyed or damaged.[51]

The DRC estimates for the assets for which they are given can be considered to be approximate current market value estimates. This is because the value of an asset to a firm is generally the present value of the expected future cash flows. If, however, as is usually the case, this is above the DRC of the asset, the firm will not pay more than DRC, assuming it can buy (or lease) second hand assets.

The estimates of the other cost components are at current market values. The result is that the estimates labeled Replacement Cost are reasonable indicators of the costs that would be incurred restoring the damage that resulted from the earthquakes.

The estimate labeled “Depreciated Replacement Cost”, however, is an indicator of the economic costs of the earthquakes, taking into account that some of the assets that were destroyed were part way through their useful economic lives but will be replaced by new assets, which will generally have a longer remaining economic life.

Only the costs (and benefits) that have been able to be expressed in monetary terms are included in the estimates. Other costs include loss of life and serious injury, the disruption to lifestyle, loss of heritage architecture and the stress from the experience and the on-going uncertainties around the future. All the figures in Table 3 should be treated as best estimates; they are inevitably subject to error.

One benefit not included in the estimates in Table 3 is the value of the reduction in crime in the region which followed the earthquake. In the year ended June 2011, the number of offenses reported to the police in the Canterbury region fell by 14.6% whereas the decline in the rest of the country was only 4.6% (Figure 1).

Table 3: Estimated Costs of Christchurch Earthquakes, 2010-2012

	Replacement Costs		Depreciated Replacement Costs	
Direct Costs	$NZm	%	$NZm	%
Households:				
- Dwellings	12,947		8,674	
- Value of residential land losses	911		911	
- House contents and personal property	862		431	
- Motor vehicles	4		4	
- Accident and emergency medical treatment	9		9	
	14,733	47.6%	*10,029*	53.6%
Commercial and Industrial (C&I)				
- Buildings	9,306		3,071	
- Value of red-zoned former C&I land	3		3	
- Plant, machinery and equipment	362		181	
- Motor vehicles	1		1	
- Stocks	702		702	
	10,374	33.5%	*3,958*	21.2%
Infrastructure				
- Roads - local and state highway	801		481	
- Electricity distribution network	70		42	
- Electricity transmission network	7		4	
- Gas distribution network	-		-	
- Sewage systems	924		554	
- Stormwater systems	119		71	
- Water supplies	156		94	
- Solid waste disposal systems	12		9	
- Telecommunications networks	57		43	
- Port assets	116		29	
- Airport assets	3		3	
	2,265	7.3%	*1,330*	7.1%
Local government				
- Buildings	135		45	
- Sports facilities, parks and reserves	59		30	
	194	0.6%	*74*	0.4%
Central government				
- Buildings	85		43	
- Value of red-zoned former government land	1		1	
- Other	1		1	
	86	0.3%	*44*	0.2%
Total Direct Costs	**27,652**	89.4%	**15,435**	82.5%
Indirect Costs				
GDP				
- GDP lost in Canterbury	3,287	10.6%	3,287	17.6%
- GDP gains in rest of New Zealand	-822	-2.7%	-822	-4.4%
Additional travel costs				
- Schools	7		7	
- Other intra-regional	5		5	
- Other extra-regional	5		5	
Temporary relocation costs				
- Households	300	1.0%	300	1.6%
- Other	482	1.6%	482	2.6%
Value of land reclaimed at Lyttelton	-20		-20	
Cost of temporary replacement for AMI stadium	28		28	
Total Indirect Costs	***3,272***	10.6%	***3,272***	17.5%
Total Direct and Indirect Costs	***30,924***	100.0%	***18,707***	100.0%

Sources: See Appendix I.

Figure 1: Changes in Offences Reported to the Police, 2006-2011
June year annual percentage changes

Source: Statistics New Zealand.

Table 4 sets out estimates of the contributions by different groups – insurers, households, Government, local authorities, donors, and commercial and industrial firms – to the estimated total replacement cost of the impact of the earthquakes. Appendix II provides details of how these estimates have been derived using the data available at the end of June 2012. The estimates are in New Zealand dollars.

By far the major contribution to the total replacement cost of $NZ30.9 billion will come from insurers; in total $NZ24.1 billion, or 78%. The central Government (i.e. the New Zealand taxpayer) is the second most significant contributor when the fact it tops up EQC's funds for all claims against it exceeding $NZ4.0 billion dollars for any one event. The third most significant contributor group is households, which bear an estimated 7.7% of the total replacement cost or about $NZ2.4 billion. A significant component of the cost to households is the reduction in incomes.

Table 4: Contributions to Replacement Cost of Christchurch Earthquakes, 2010-2012

	$NZm	$NZm	%
Insurance and reinsurance (excluding EQC and AMI and ACC)	13,317		
EQC (Including $4.2b sum reinsured and Government's contribution)			
- Houses	10,194		
- Contents and personal property	566		
- Residential land	27		
ACC payments for treatment of injuries etc.	9		
Total contribution from insurers		*24,113*	78.0%
Central government (excluding EQC)			
- Financial support to AMI	100		
- Repair & replacement of state owned assets	85		
- Contribution towards repair & replacement of local infrastructure assets	653		
- Purchase of red-zoned residential land and related costs	838		
- Demolition of CBD properties	112		
- Payments to local government for response and recovery costs	82		
- Other earthquake related central government expenses	522		
Total contribution from central government		*2,391*	7.7%
Private charity			
- Organised	214		
- Families and friends	20		
		234	0.8%
Households			
- Assets losses	806		
- Loss of income	1,282		
- Temporary relocation costs	270		
		2,358	7.6%
Commercial and industrial businesses			
- Assets losses	182		
- Loss of business profits	604		
- Temporary relocation costs	241		
		1,027	3.3%
Local government		802	2.6%
Discrepancy		- 1	0.0%
Total contributions to losses at replacement cost		**30,924**	100.0%

Sources: See Appendix II.

Households will also indirectly bear the costs of the other groups through future taxes (central government), future rates (local government property taxes), higher charges or rates (monopoly infrastructural providers) and higher future insurance premiums (insurance). The table does not reflect the indirect incidence of the costs.

All the figures in Table 4 should be treated as best estimates; they are inevitably subject to error.

A significant point to emerge from Table 4 is that an estimated 78% of the $NZ30.9 billion of direct and indirect costs of the earthquakes at replacement cost will be covered by insurance of one form or another.

Our estimate of the cost as $NZ30.9 billion at replacement cost is not out of line with other aggregate estimates. To date there are no other estimates for which a detailed breakdown is available. In October 2011, the Reserve Bank of New

Zealand's estimated, before the final major quake, the costs to rebuild as between $NZ15 billion and $NZ25 billion.[52] Subsequently, however, in late January 2012, the Reserve Bank revised its figure upwards to $NZ30 billion. It is clear this estimate is on a replacement cost basis.[53] Swiss Re, a reinsurance provider, estimated in late 2011 that the economic losses from the Christchurch earthquakes, excluding the December 2011 earthquake, was approximately $US18 billion[54] ($NZ22.9 billion). In late October 2011, Treasury warned that the costs of the quakes could be as high as $NZ30 billion.[55] It is clear from the context that Treasury's estimate was on a replacement cost basis as it refers to changes in building standards increasing costs.[56]

3.1.4. Loss of Population

According to official estimates by Statistics New Zealand,[57]a government agency, the population of the Canterbury Region, which includes Christchurch City, fell by an estimated 5,000 in the year to June 2011. The components of this change were natural increase of 2,600, as births exceeded deaths by this number, and net emigration of 7,600 from the region. In the four years ended 30 June 2010, the population of the Canterbury Region is estimated to have increased on average by 6,400 with 3,200 of the increase being from net immigration and 3,200 from natural increase. These figures suggest that the earthquakes resulted in a reduction in the natural increase in the region by approximately 600, a turnaround in migration of 10,800 and a gross reduction in regional population of around 11,400 from what it otherwise would have been if normal growth as experienced in the previous four years had continued. On the 30 June 2010 the population of the Canterbury Region was 565,700, so a reduction of 11,400 amounts to a change of 2.0%.

According to the same source,[58] the population of Christchurch City was 376,700 on 30 June 2010, but fell by 8,900 in the subsequent year to 30 June 2011. The reduction was composed of a natural increase of 1,700 and net emigration of 10,600. In the four years ended 30 June 2010, the population of Christchurch City is estimated to have increased on average by 3,700 with natural increase accounting for 2,200 per year and net immigration for 1,600. These figures suggest that the earthquakes resulted in a reduction in the natural increase in Christchurch City by approximately 500, a turnaround in migration of 12,200 and a gross reduction in the

city's population of around 12,700 from what it would have been if 'normal' growth had continued. A reduction of 12,700 amounts to 3.4% of the population as at 30 June 2010.

There are currently no official estimates of the populations of the Canterbury Region and Christchurch City after June 30 2011. However, there were significant earthquakes in June 2011 and again on 23 December 2011. The indications from media reports are that there has been further net emigration from the region and the city since 30 June 2011, and that the population losses in both have increased in absolute and percentage terms.

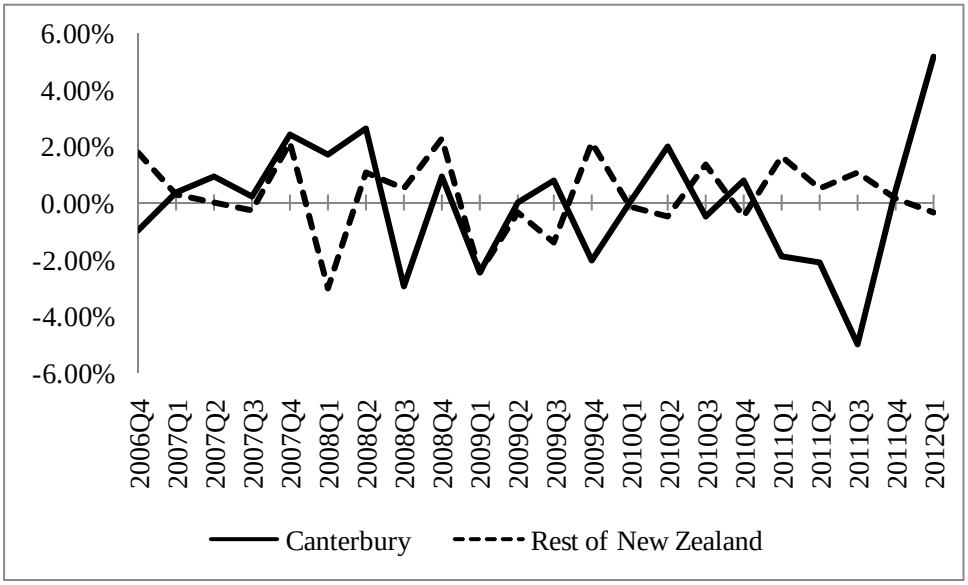
3.1.5. Changes in Labor Inputs

Employment in the Canterbury Region fell by 26,800 persons, or 8.0%, in the year to September 2011 and reached its lowest level since June 2004 (Figure 2). A very slight increase in employment occurred in the December 2011 quarter followed by a substantial increase of 15,900 persons, or 5.1% in the March 2012 quarter. In the rest of the country, employment grew by 51,200 persons, or 2.8% over the year to September 2011 and was relatively static in the following six months to March 2012.

During 2010 employment had been relatively static in the Canterbury Region, having fallen prior to this by about 4% from its peak in mid-2008. This suggests that over the year to September 2011, employment in Canterbury fell below what it would have been without the earthquakes by between 30,000 and 35,000 persons, or around 10%. A 10% reduction in labor inputs is a significant change, as is the increase of 17,200 persons, or 5.6%, in the six months after September 2011.

Figure 2: Changes in Persons Employed, 2006-12

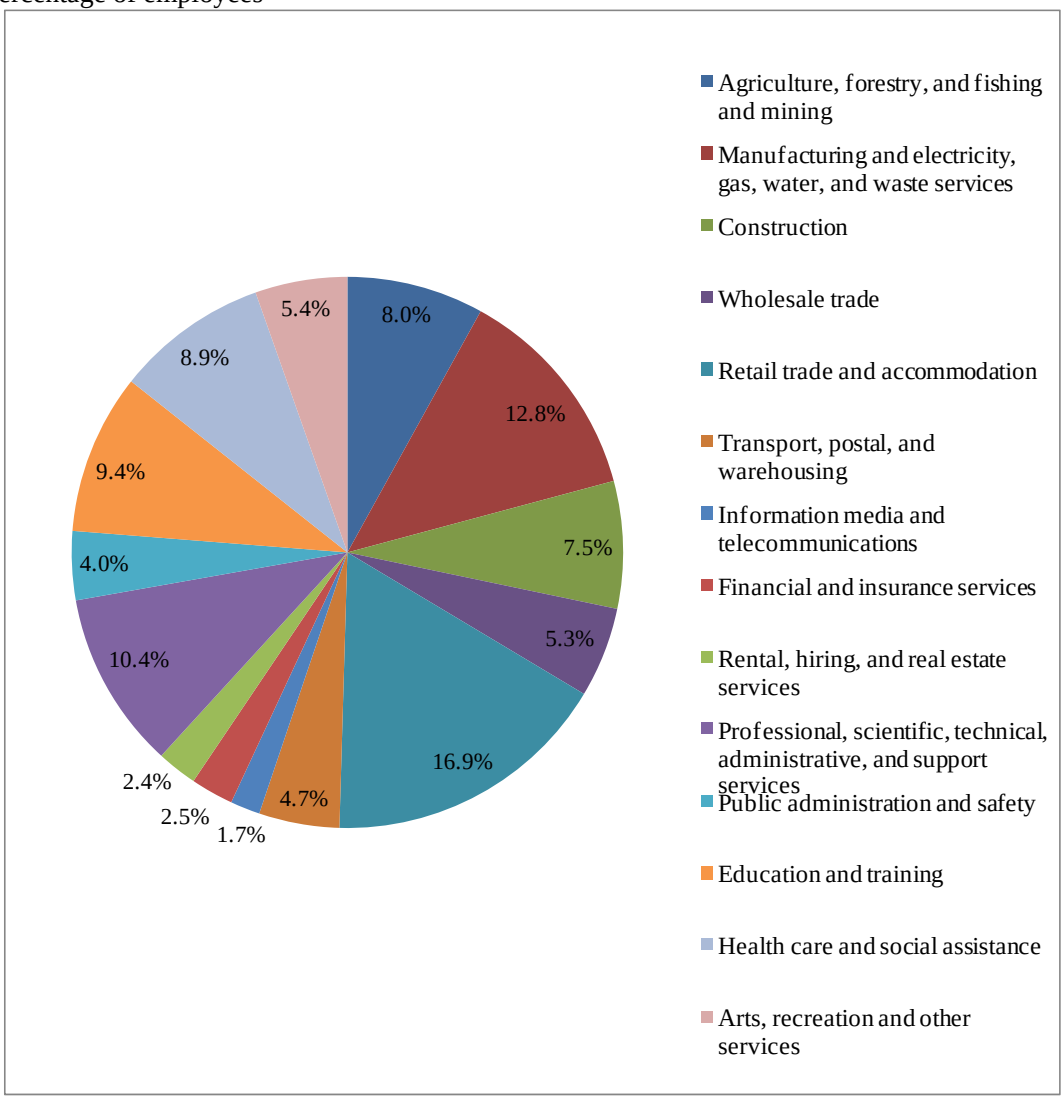
Quarterly percentage changes



Source: Statistics New Zealand.

Figure 3 shows the sector breakdown of the Canterbury labor force of 335,200 in September 2010. The sector with the largest share of employment was retail trade and accommodation (16.9%). This reflected the importance of tourism to the Canterbury economy. In the rest of New Zealand, 15.1% of employees were engaged in this activity. The next largest proportion of employees in Canterbury were engaged in the manufacturing and operating utilities (12.8%), followed by professional, etc. services (10.4%) and education and training (9.4%). Both manufacturing and education and training had larger shares of total employment in Canterbury than in the rest of the country.

Figure 3: Employment by Sector in Canterbury, Sept 2010
Percentage of employees



Source: Statistics New Zealand

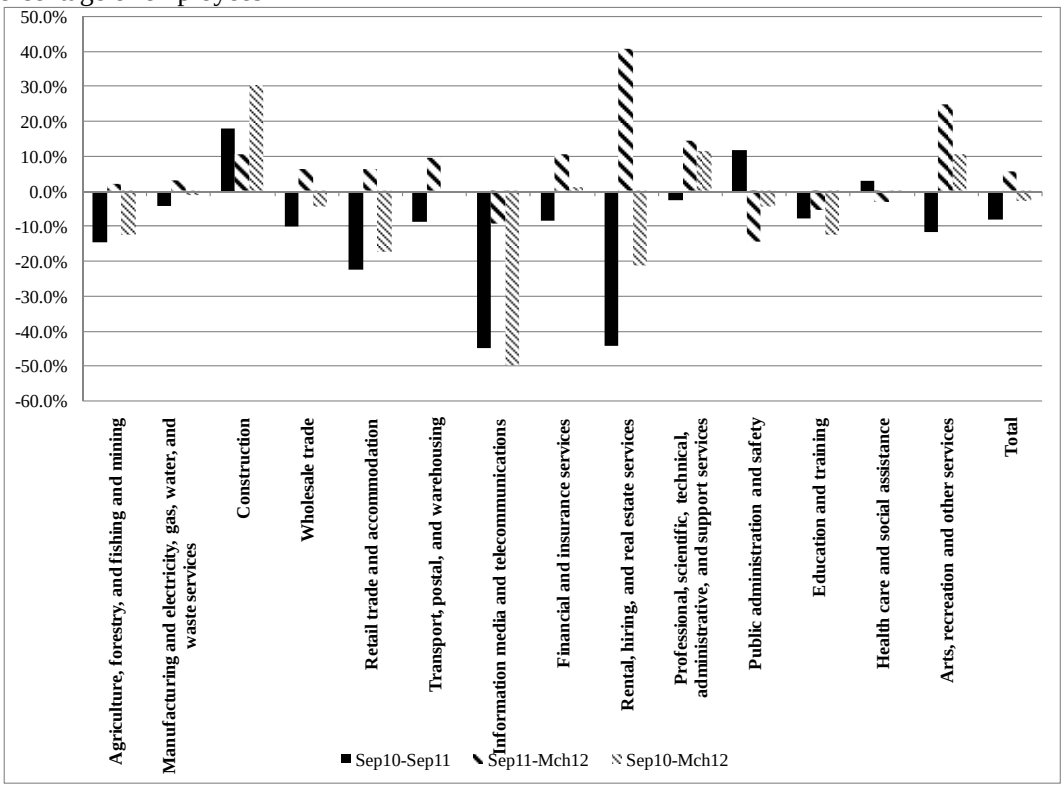
The impact of the earthquakes on employment in the region had diverse effects. This can be seen from Figure 4.

The job losses in the Canterbury Region in the twelve months ended September 2011 were widespread among sectors, but particularly prevalent in the retail trade and accommodation sector that is more heavily concentrated in the extensively damaged CBD. In percentage terms, the losses in information media etc. approached 50.0%, but the sector was a relatively small percentage of total employment (1.7%). The only sectors to show job gains in the twelve months ended September 2011 were construction, public administration and professional services. Employment in

manufacturing was relatively static.[59] In the rest of New Zealand over the same period there was employment growth in almost all sectors.

Figure 4: Changes in Canterbury Employment by Sector, Sept 2010 – March 2012

Percentage of employees



Source: Statistics New Zealand

In the period from September 2011 until March 2012, employment grew in the Canterbury region in most sectors. The exceptions in addition to the small information media sector were public administration and safety, education and training and health care and social assistance. Employment in the rental, hiring and real estate sector, which has fallen over 40% in the year to September 2011 rose by roughly the same amount in the six months to March 2012. This reflected the return of activity to the property market as people abandoned red-zoned and other residential properties and moved elsewhere, often within Christchurch.

3.1.6. Loss of Output

Regional GDP data are not officially compiled in New Zealand. However, the New Zealand Institute of Economic Research (NZIER) has long produced and

published its own estimates. According to these estimates the GDP of the Canterbury region fell by around 5-7% in the year to September 2011. The decline in Canterbury was, however, partly offset by resilience elsewhere in New Zealand.[60]

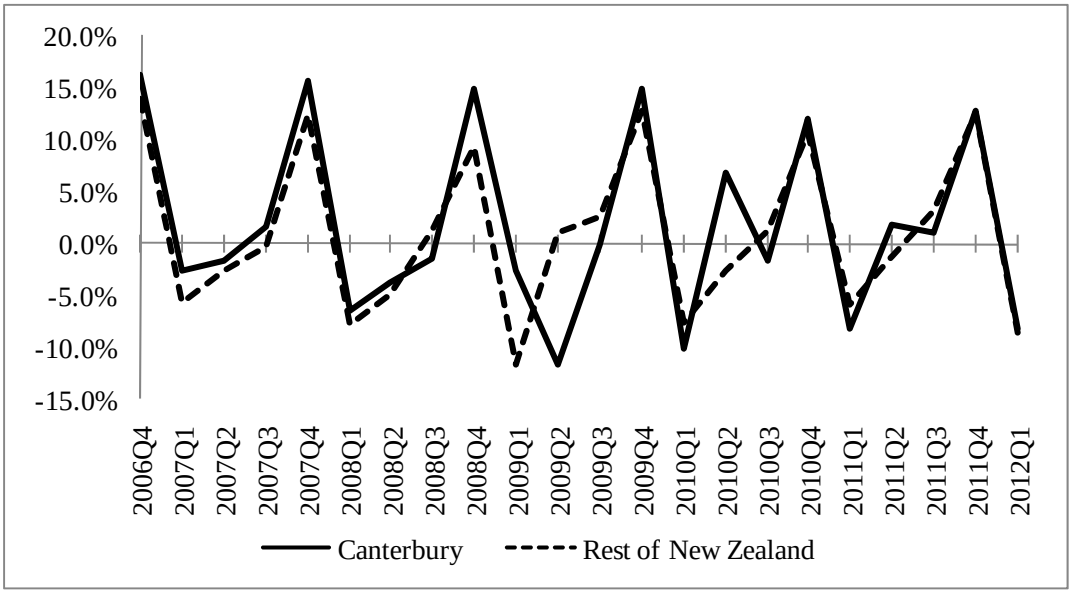
NZIER's *Quarterly Survey of Business Opinion* for the September 2011 quarter showed that Canterbury businesses were expecting a bounce back from the initial disruption in the six months to March 2012 and that investment activity in the region would pick up sharply, especially for building investment and construction labor hiring intentions.[61]

3.1.7. Other Economic Indicators

Electronic transaction data appears to indicate that retail spending in Canterbury dropped below what it would have been if it had of followed the national trend by between $NZ25 million and $NZ40 million per month, or by approximately 7 – 11%.[62] However, no similar drop in expenditure is evident in the quarterly retail sales statistics shown in Figure 5. The drop off in electronic transactions reflected a reduction in payments by this means as access to electronic payment facilities was disrupted.

House sales nearly stopped in Canterbury immediately after the major quakes but in recent months have bounced back to be more in line with national trends. House prices appear to be rising in Canterbury, compared to flat prices elsewhere but the increase is still very modest at less than 5% per year. The inventory of houses for sale relative to numbers of house sales has declined in Canterbury much more than in the rest of the country.[63]

Figure 5: Changes in Retail Sales, 2007-2012
Quarterly percentage changes

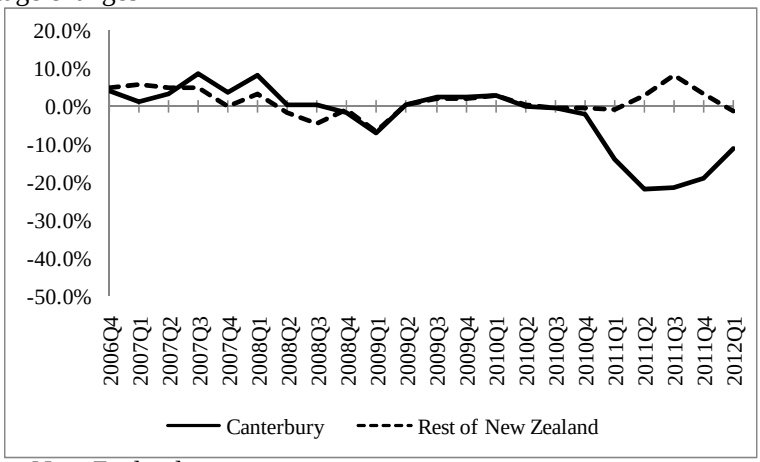


Source: Statistics New Zealand.

The number of bed nights in accommodation places in the Canterbury region fell sharply after the earthquakes and had not completely recovered by the December quarter 2011 (Figure 6). This is despite the people who have been brought in to Christchurch temporarily to undertake assessments and help with the recovery phase.

The number of bed nights in New Zealand reaching an all-time monthly high of approximately 2.5 million in October 2011, whereas those in Canterbury were 27% below their previous peak.[64]

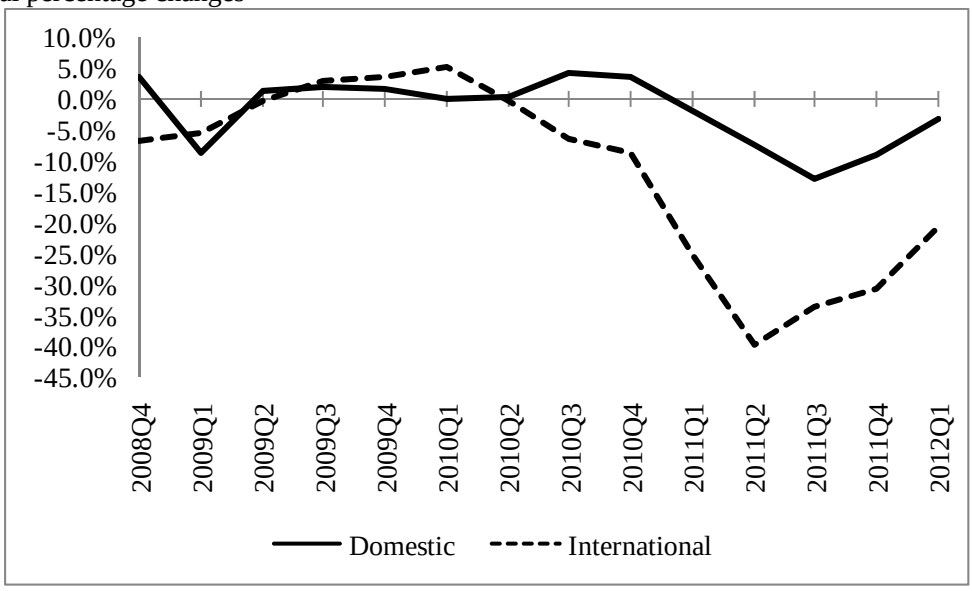
Figure 6: Changes in Total Guest Nights, 2006-2012
Annual percentage changes



Source: Statistics New Zealand.

From Figure 7 it is clear that the fall in the number of international guest nights in Canterbury was far more significant than the fall in the number of domestic guest nights. Of the major population centers in New Zealand, Christchurch is the one most dependent upon international tourism and the earthquakes severely disrupted this industry.

Figure 7: Changes in Canterbury Guest Nights, 2008-2012
Annual percentage changes

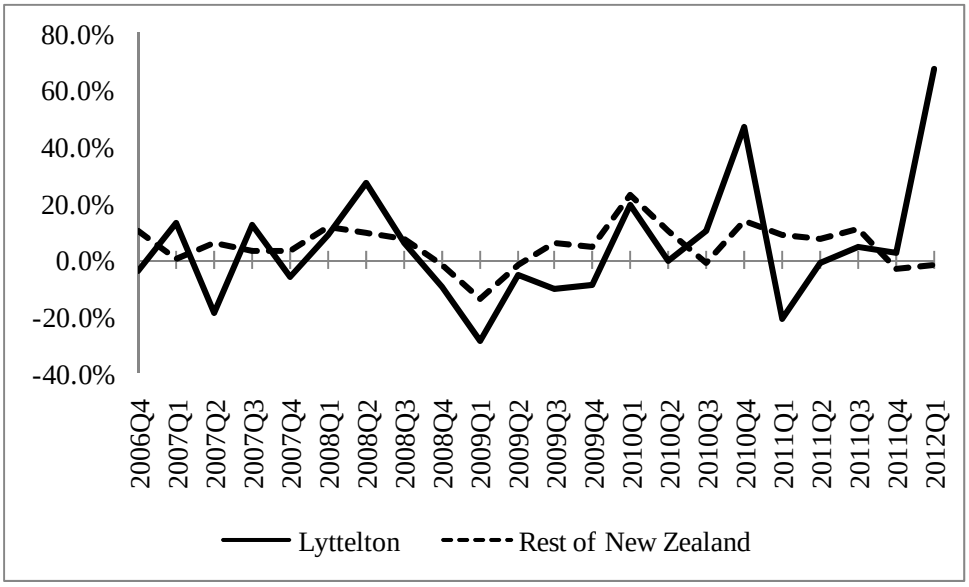


Source: Statistics New Zealand.

Despite very significant damage to the physical assets of the region's major port at Lyttelton, exports through the port were reasonably resilient after the earthquakes and reached an all-time high by value late in 2011.[65]

In terms of volumes of cargo, the throughput of Lyttelton has always been quite volatile. This is partly due to the importance of coal exports to the port; these vary significantly depending on the arrival times of ships. It is also partly due to the importance of primary produce in the exports through the port. Small variations in the timing of the seasonal meat kill and grain harvest can have a large impact on volumes exported in a quarter.

Figure 8: Changes in Trade Volumes through Seaports, 2006-2012
Annual percentage changes, gross weight



Source: Statistics New Zealand.

Figure 8 illustrates the volatility of trade through Lyttelton and that there has been no obvious impact on this trade as a result of the earthquakes until the March quarter 2012. In that quarter total trade through the port was 67.2% greater than in the corresponding quarter the previous year. Import volumes rose 105% and export volumes by 55%. It is likely that imports for reconstruction activities contributed to the sharp increase in imports and total trade.

The impact of the earthquake on the Government's fiscal position has been significant. Both central and local government faced large costs. The central government has purchased residential properties in the zones that will be abandoned for geotechnical reasons. This is estimated to have cost approximately $NZ840 million. It has also offered financial support to AMI, a major insurer of households based in the region affected by the earthquakes. AMI held inadequate re-insurance to cover the string of earthquakes. The cost to the Government will be approximately $NZ100 million.

In addition to these costs, the Government faced significant expenses for welfare and emergency services and has to fund the on-going operation of the Canterbury Earthquake Recovery Authority (CERA), the special statutory body the Government established to manage the recovery of the region. In addition, the Government is the owner of EQC, a New Zealand Government agency providing natural disaster

insurance to residential property owners, and underwrites the claims on it in excess of $NZ4.0 billion for any single event. The earthquakes in Christchurch have been considered to be several different events for the purposes of EQC liability.

The Reserve Bank estimated the Government's earthquake-related expenditure at $NZ13.6 billion in the June 2011 fiscal year.[66] This figure includes the expenses of EQC. Earthquake-related expenditure were a major contributor to the marked deterioration in the Government's operating deficit in the 2010/11 year and this contributed to a downgrading of New Zealand's long term sovereign rating by Standard and Poor's to AA.[67] The Government has tightened its expenditure in general in response to the deterioration in its fiscal position.

3.2. Impacts of Disasters on Urbanization in New Zealand

3.2.1. Short-term Relocations

It is too early to identify the longer-term impact of the September 2010 – December 2011 earthquakes on the pattern of urbanization and production networks in Christchurch and New Zealand. However, the short-term impacts that have emerged are interesting, and suggest a number of points.

The earthquake on 22 February 2011 was by far the most destructive. It very nearly demolished the Christchurch CBD and led to it being subject to a 24 hour a day curfew that was still in place in March 2012 in the worst affected areas. Apart from members of the emergency services required to be in the area for their work, the public were excluded from most of the CBD for several months. This included all those that owned or worked in buildings in the city center.

Within hours of the very damaging February 2011 earthquake, service industry businesses located in the CBD – lawyers, accountants, financial advisers, banks, architects, dentists, doctors etc. – began relocating, mainly to the western side of the city, where damage to infrastructure such as roads, sewage, water and electricity was less severe and most buildings were either lightly or not damaged. They moved into former warehouses and distribution centers; in fact, into almost any space they could find. Other businesses relocated to garages and parts of dwellings in the suburbs, again mainly in the west of the city. Within days of the earthquake, a large

proportion of former CBD located businesses, apart from retail shops, were operating from temporary premises elsewhere in the city.

A local commercial radio station set space aside on its webpage for firms to record where they had relocated from and to.[68] The service was provided free. The number of firms which used this service was small - approximately 90 - but the majority were originally located in the CBD. An analysis of the data reveals that of the 72 CBD firms, no less than 50.0% shifted to addresses in Sydenham, Addington or Riccarton. These three areas are adjacent to the CBD and form an arc to its south and west. No less than 77.8% of the CBD firms shifted to a suburb adjacent to the CBD.

The Christchurch telephone directory covers the greater Christchurch area and is usually produced annually. The yellow pages volume of the directory list businesses by the industry or service they provide. The 2010/11 volume was collated in August 2010, just before the first earthquake. The 2011/12 volume was collated in September 2011.

Table 5 contains a comparison of the listing in these directories of the accountants and auditors, lawyers and solicitors, barristers[69] and dentists recorded as located in the CBD in the 2010/11 volume. The popularity of relocating to the CBD fringe suburbs of Sydenham, Addington and Riccarton, especially by lawyers and solicitors can be seen from the data. Interestingly, while no accountants and auditors were recorded as having moved to the Merivale-Papanui area[70], and only 9.0% of firms of lawyers and solicitors, 25.8% of dentists are recorded as having done so.

Table 5: Relocation of Selected Professional Firms from Christchurch CBD, 2010 -2011

Numbers and percentages of firms

Professional occupation	Same location	New location				No location	Total
		Elsewhere in CBD	Sydenham, Addington & Riccarton	Merivale & Papanui	Other		
Accountants and auditors	28	6	13	0	30	3	80
Lawyers and solicitors	21	7	26	8	16	11	89
Barristers	20	2	7	6	4	10	49
Dentitsts	11	2	3	8	5	2	31
Total	80	17	49	22	55	26	249
Accountants and auditors	35.0%	7.5%	16.3%	0.0%	37.5%	3.8%	100.0%
Lawyers and solicitors	23.6%	7.9%	29.2%	9.0%	18.0%	12.4%	100.0%
Barristers	40.8%	4.1%	14.3%	12.2%	8.2%	20.4%	100.0%
Dentitsts	35.5%	6.5%	9.7%	25.8%	16.1%	6.5%	100.0%
Total	32.1%	6.8%	19.7%	8.8%	22.1%	10.4%	100.0%

Source: Calculated from Christchurch yellow page phone books for 2010/11 and 2011/12.

Prior to the earthquakes, Riccarton already had clusters of legal and accounting firms, and this, along with the larger size of offices available in the area was undoubtedly an attraction to those firms that had to relocate. Dental practices tend to be small and not dissimilar in terms of the office space they require to medical specialists. Merivale-Papanui is a popular location for medical specialists because of its proximity to the two major private hospitals in Christchurch. That a significant proportion of dental practices needing to relocate should have been drawn here by the kinds of space available is not surprising.

Those recorded in the yellow pages as "barristers" rather than as "barristers and solicitors" or as "lawyers" are sole practitioners. It is common for several barristers to operate from the one building or chamber, and when they do they usually share secretarial and other support. However, they are sole practitioners. Many of those with no location recorded in the 2011/12 yellow pages have undoubtedly set up practice from their home address. There are also several instances of barristers recorded as shifting to the same building as others with whom they were formerly co-located.

Despite the disruption created by the series of major earthquakes and the speed with which decisions often had to be made, what is very clear is that the forces that

lead to agglomeration of businesses were still at work when sites for relocation by professional firms and sole practitioners were being chosen.

In October 2011 the Department of Labour conducted a telephone survey of 1,689 employers trading before 4 September 2010 in the greater Christchurch area.[71] The survey did not cover owner operated businesses without any staff. One of the questions related to whether the workplace had partly or fully relocated as a result of the earthquake. Tables 6 and 7 summarize the results according to staff size and industry in which the workplace operates.

Table 6: Proportion of Workplaces that Relocated Following the Earthquakes by Staff Size, October 2011

Percentage of workplaces

Staff size	Did not relocate	Relocated			Total
		Permanent	Temporary	Unsure	
1 to 5	72.0%	9.8%	15.1%	3.0%	100.0%
6 to 9	77.9%	10.0%	8.8%	3.3%	100.0%
10 to 24	70.3%	12.0%	15.5%	2.2%	100.0%
25 to 49	74.9%	5.5%	13.7%	5.9%	100.0%
50 to 99	68.2%	12.6%	14.3%	4.8%	100.0%
100+	62.9%	7.7%	18.8%	10.6%	100.0%
Total	72.4%	10.0%	14.2%	3.3%	100.0%

Source: Department of Labour (2011: 13), Table A5

On average, 27.6% of the surveyed workplaces relocated, and 72.4% did not. In general, the larger workplaces – those with staff of 50 or more – were more likely to have relocated than smaller workplaces. Approximately 35% of the larger workplaces relocated compared with approximately 25% of the smaller ones. Of the workplaces that relocated, 36.4% thought in October 2011 that the change was permanent, 51.6% that it was temporary and 12.0% were unsure.

Table 7: Proportion of Workplaces that Relocated Following the Earthquakes by Industry, October 2011

Percentage of workplaces

Industry	Did not relocate	Relocated			Total
		Permanent	Temporary	Unsure	
Primary, Transport, Utilities	87.6%	7.1%	4.8%	0.4%	100.0%
Public, Health, Education	66.3%	6.1%	23.8%	3.7%	100.0%
Professional, Scientific and Technical Services	40.2%	13.3%	39.3%	7.2%	100.0%
Manufacturing	84.0%	10.9%	2.7%	2.4%	100.0%
Construction	78.0%	5.2%	13.2%	3.6%	100.0%
Retail, wholesale	79.4%	12.2%	5.9%	2.5%	100.0%
Hospitality	88.4%	7.5%	3.6%	0.5%	100.0%
Other	64.8%	13.3%	17.5%	4.4%	100.0%
Total	72.4%	10.0%	14.2%	3.3%	100.0%

Source: Department of Labour (2011: 13), Table A6

No less than 59.8% of the workplaces engaged in professional, scientific and technical services relocated as a result of the earthquake. Of the public, health and education workplaces, which are predominantly in the government sector, 33.7% relocated. At the other end of the scale, only 11.6% of the hospitality workplaces shifted and only 16% of those engaged in manufacturing.

The new locations did not initially have the car parking facilities, bus services, coffee shops, and restaurants, lunch bars etc. that were a feature of the CBD and supported its service industry. However, the coffee bars, lunch bars and restaurants very quickly followed their customers. In some instances they did this by subleasing space from new tenants, the employees of whom they had served in the CBD. In other cases, they relocated to trucks and vans on the street side.

The CBD retailers found it much harder to relocate. Some were able to move to vacant shops in the suburbs and in suburban malls, but there was a limited supply of these, and some of the malls had also sustained damage and were temporarily shut. After several months a temporary shopping area was opened in the former heart of the retail area of the CBD. Shops from all over the former CBD agglomerated into a new center made up of 40 very colorfully painted and decorated shipping containers.

They decided to relocate to one relatively small area rather than re-open close to their former locations because they considered this would attract customers. This has turned out to be the case. The opening of the temporary shopping center– Re:Build – was timed to coincide with a festival and public holiday in the city and with the re-opening of a major department store whose relatively modern building was able to be repaired.[72]

3.2.2. Longer-term Issues: Theory

One interesting issue raised by the literature on natural disasters is whether the Christchurch CBD will ever be completely reconstructed and how long it will take for the city more generally to recover.

Members of the Faculty and students of the Kennedy School of Government at Harvard University have worked on the recovery of New Orleans following its devastation in 2005 by Hurricane Katrina and the flooding it produced.[73] This followed on from work they had undertaken during the recovery from the earthquake in San Francisco in 1989. More recently they have also been working with Los Angeles following an earthquake there in 2007 and with the government of Chile after that country's 8.8 magnitude quake on 27 February 2010. From experience in these recoveries and from observations of recoveries from other disasters, the director of Harvard's New Orleans Recovery Initiative, Douglas Ahlers, and colleagues have developed several concepts relating to the dynamics of recovery, repopulation and reinvestment following natural disasters.[74]

Ahlers argues that much of disaster recovery where there has been a major loss in physical capital, as there has been in Christchurch, is an investment problem, and, more specifically, an investor confidence problem. Following a major natural disaster of this type, thousands of individuals have to make the decision of whether to re-build or not. Because of the existence of agglomeration benefits, the pay-off to an investor from a decision to re-build is influenced by the decisions of all the others in a similar locality as to whether they will rebuild or not.

Agglomeration benefits are the economic advantages in terms of higher productivity and lower costs firms (and individuals) obtain from locating near each

other; i.e. from agglomerating. The advantages arise because of positive externalities through:

- the increased size of the pool of skilled labor available to the firms;
- the improved access to specialized goods and services and their lower cost due to increased competition among suppliers;
- the improved ability to specialize; and
- technological spill-overs in the form of quicker diffusion or adoption of new ideas.

The more people deciding to re-build in a locality, the higher the pay-off, and vice versa. So the probability an individual will decide to re-build is a function of his or her assessment of whether others will decide to rebuild or not. The situation is analogous to the prisoner's dilemma problem often analyzed using game theory.

The upshot is that there can be two equilibrium positions. One in which "everyone" tips in, and decides that they will re-build because they believe everyone else will re-build. The other one in which "everyone" tips out, and decides that, since it is unlikely that others will re-build, they will not re-build but instead invest elsewhere, where agglomeration benefits are known to be available, or in another activity.

In the short-term, investors can decide to "wait-and-see". In fact, from the point of view of an individual investor, this is the dominant strategy. However, the longer an investor "waits-and-sees" the more others faced with the same decision will take their inaction as evidence that they will not be re-building and this will lower the probability that re-building will actually occur.

The implication of this analysis is that uncertainty over time will slow and may even kill a recovery and reconstruction. For this reason, policy makers should avoid or rectify factors that will increase investor uncertainty, such as:

- lack of a clear leader of the recovery in whom or which people have confidence;
- where and what can be re-built not being settled quickly;
- who will provide affordable insurance for re-built structures and infrastructure, and on what terms; and

- how quickly infrastructure needed to support any rebuilding will be restored or provided in new locations.

A second implication is that recovery will tend to occur in pockets, interspersed among pockets not yet recovering. The resulting patch-work quilt of areas where re-building is occurring interspersed with other areas not currently being re-built was a noticeable feature of the recovery of the lower income areas of New Orleans.

A policy implication is that focusing recovery efforts on particular areas is likely to be more successful. Moreover, the most effective place to concentrate policy interventions is in the areas which are closest to the tipping point; closest to the point where the balance of investor decisions will be easiest to switch from "wait-and-see" to a decision to re-build.

Other implications are that recovery and reconstruction is less likely the easier it is for people to:

- abandon an area or decide not to re-build because, for example, the area was already in decline and/or still had surplus fixed assets relative to needs after the disaster;
- migrate elsewhere because they have the opportunity to do so as jobs are readily available; and
- shift because they have limited financial capital locked up in land or other assets in the area affected by the natural disaster that they will have to abandon or sell for a low return if they do not re-build.

In regard to the last factor, holding insurance cover for disaster damage to buildings, chattels, etc. means that, in the event the insured property is destroyed in a disaster, what was previously a fixed asset becomes a liquid and highly mobile one immediately the insurance pay-out is received.

For this reason, an implication of the Harvard Kennedy School model of recovery and reconstruction is that high levels of assets covered by insurance may not translate into rapid re-building following a disaster. The insurance pay-outs may facilitate re-building by giving parties the financial resources to do so, but they may also make it easier for people to relocate. This will be particularly the case if "insurance" compensation covers not only losses of buildings and chattels but also

covers land and, for businesses, lost income and profits, as has been the case to some degree in Christchurch.

The Harvard Kennedy School are not the only ones to note the relevance of the new economic geography concept of agglomeration to the study of the impact of natural disasters, and specifically that one of its implications is that the shock associated with a natural disaster may in some circumstances lead to the relocation of an industry. Okazaki, Ito and Imazuimi have investigated the long-run impact of the Great Kanto Earthquake of 1923 on the geographic distribution of industries in the Tokyo Prefecture.[75] They found that while the effects of the temporary shock on most economic aspects had basically dissipated by 1936, the re-location of the machinery and metal industry following the earthquake was persistent and remained even in 1936.[76]

3.2.3. Longer-term Issues: Application to Christchurch

Will the Christchurch CBD ever be completely reconstructed and how long will it take for the city more generally to recover? Will the professional service organizations that shifted from the CBD to new locations in the days after the 22 February 2011 earthquake ever return to the CBD? Some have had to take long leases to secure new office accommodation and once the transport and other services are more fully developed in and around their new locations it is likely many will want to stay, especially since they have agglomerated at the new locations with other compatible organizations.

Will the mainly private owners of the city's numerous two and three storey masonry-fronted buildings invest to replace them or use the proceeds from their insurance policies to invest elsewhere, or in other assets? These buildings were generally old and had poor lighting, heating and space utilisation. Many were not heavily occupied and the economics of rebuilding them in a modestly growing city like Christchurch appears to be challenging.

Will the retail activity in the CBD fully recover? Retailing in the Christchurch CBD has been an activity in decline since the 1960s as a result of the local government encouraging the development of suburban shopping malls. Christchurch currently has eight major suburban malls ringing the CBD. One of the lessons from previous natural disasters is that an activity in decline at the time may never recover,

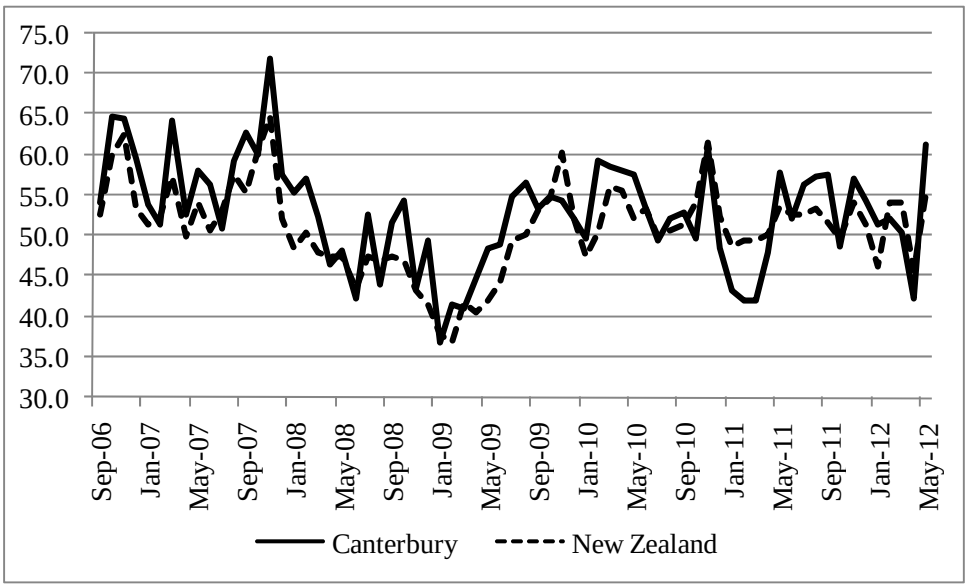
and at best will take a very long time to do so. A scenario the Harvard School literature suggests is more than possible is that the CBD, even when fully redeveloped, will have a smaller and more focused retail shopping area than it had prior to the earthquakes.

Will the people with houses in the residential red zone, where the Government has offered to buy the land at 2008 market value, relocate within Christchurch or shift elsewhere? Property owners in this situation, who have replacement insurance on their buildings, will be compensated for the land at 2008 market value by the Government and for the buildings at current replacement cost by their insurance company. In short, they will receive close to their entire equity in their residential property in cash. This applies to virtually all the estimated 8,200 residential red zone owners, as insurance coverage in New Zealand is extremely high, and is usually on a replacement basis for houses,

However, the replacement cost of the land in Christchurch is likely to be higher than most will receive from the Government. This is partly because land prices in Christchurch are likely to increase in response to demand relative to the reduced supply and partly because the areas condemned were among the areas with the lowest values in the city. This suggests there is a real possibility that some will decide to relocate elsewhere in New Zealand or Australia, rather than relocate within Christchurch. There are, however, only about 8,200 houses in the residential red zone, out of nearly 200,000 impacted directly. There could therefore be too few people in this situation to have more than a minor impact on the population growth and recovery of Christchurch overall.

The manufacturing sector, historically important in Christchurch, was not affected in a significant manner because it is largely located on the western side of the city outside the CBD. These areas suffered much less damage and, as a result, manufacturing is unlikely to be materially affected in future. Comparison of the Business New Zealand Performance of Manufacturing Index (PMI) for Canterbury with the index for New Zealand as a whole is consistent with the impact on Canterbury manufacturing being limited (Figure 9). The PMI is an early indicator of levels of activity in New Zealand manufacturing.

Figure 9: Business New Zealand Performance of Manufacturing Index, 2006-12
Index Numbers



Source: Business New Zealand and Bank of New Zealand.

However, as was shown in Figures 6 and 7 above, tourism is in the opposite situation. Most major hotels have had to be demolished. In addition, virtually all the city's stone heritage buildings, a major attraction to tourists from within New Zealand and beyond, have been destroyed or, at best, will be very many years in the process of being restored. Unless the city re-invents its attractions to tourists this important industry for the local economy will take a long time to recover to its former level. It is not impossible. Napier, which was devastated by an earthquake in 1931, rebuilt in Art Deco style and this is now a major tourist attraction in itself.

3.2.4. Disaster Insurance

One unusual feature of New Zealand is the widespread level of insurance against damage from geophysical, hydrological and meteorological disasters. In 1945, the New Zealand Government established the Earthquake Commission (EQC) to provide insurance for residential dwellings (including apartments and holiday houses), most personal property, and the land immediately around a dwelling against damage caused by earthquake, volcanic eruption, hydrothermal activity, tsunami, natural landslips, storm or flood damage and fire caused by any of these natural disasters.

All parties with fire insurance over a dwelling and insurance over household goods and personal property are required to pay for insurance from EQC.[77] The levy

used to be $NZ0.05 per $NZ100 insured but following the Christchurch earthquakes the rate has been tripled in order to restore the fund.

There are limits on the level of cover provided. For dwellings (i.e. house alone), the maximum is $NZ100,000. In November 2011, the median residential property (i.e. house and land) price was $NZ367,500.[78] For personal property, the maximum is $NZ20,000. Most insured parties top-up the EQC cover with private insurance so they are fully covered on a replacement basis. This extra insurance was in the past relatively cheap because insurance with EQC meant that only large claims above the maximums of EQC's coverage would fall on the private insurer. Since the Christchurch earthquake the rates for this kind of insurance have risen to reflect the greater perception of risk, but they are still affordable and obtainable by most parties outside Christchurch.

Insurance coverage levels are very high, however, partly because of the availability of EQC cover – in order to access EQC the party must hold house and/or contents insurance - and partly because New Zealand lending institutions will not advance funds against uninsured properties, and most dwelling owners borrow money to finance the purchase of a property, whether it is for their own occupation or to rent to tenants.

Although the EQC only covers residential and personal property, most businesses also carry property insurance and business interruption insurance for losses due to geophysical, hydrological and meteorological risks. This reflects the requirement of lenders that businesses hold adequate insurance cover before they will advance funds.

Over the years, EQC built up its own pool of funds as a result of its levies exceeding its pay-outs. In more recent years it bought additional cover on the international market through reinsurance organizations. Losses in excess of $NZ1.5 billion up to $NZ4.0 billion for any one event have been covered by international reinsurance. The Government covers losses in excess of $4.0 billion for any one event. Private insurance providers of the top ups to EQC cover and commercial disaster insurers also largely pass on the risks they cover to international reinsurers. Much of the financial burden of the earthquakes in Christchurch will fall in the first instance on international reinsurance businesses. In Table 4 above we estimate that

insurers and reinsurers, including EQC and the Government-owned Accident Compensation Corporation (ACC) will contribute $NZ24.1 billion of the total $NZ30.9 billion, or 78.0% of the total cost at replacement cost.

We have already noted one of the potential consequences of the high level of insurance coverage. Parties receiving insurance payments may be tempted to use their liquidity in the asset they now hold to relocate elsewhere in New Zealand or overseas in places such as Australia.

Another related issue is that because of the size of the losses sustained, and the on-going seismic activity in the Canterbury regions, many insurers and reinsurers are reluctant to extend cover to new or replacement buildings in the region. This is now starting to hold back redevelopment and, as a result, creating uncertainty among investors; uncertainty which could lead to an unwillingness to invest and retard the time of the recovery, possibly, significantly. It remains to be seen how long it will take for the insurers and reinsurers to re-enter the Christchurch market.

4. Policy Recommendations

4.1. National Level

New Zealand has a comprehensive disaster monitoring and management regime, and while it is always possible to improve any regime of this kind, the only obvious policy points to emerge from the Christchurch experience are the need to more adequately assess the geotechnical characteristics of land when determining the use to which it should be put and the danger of unreinforced masonry fronts on “historic” buildings.

Of pressing concern at present is the need to create and maintain momentum in the reconstruction of Christchurch, to avoid the risk of the city never returning to its full economic strength and potential. There are several factors working against momentum in reconstruction that need to be overcome.

First, the extended period over which aftershocks have occurred, and the sizable magnitude of several of them, has delayed the return to the market of insurers and reinsurers. According to the telephone survey of workplaces in the greater Christchurch area conducted by the Department of Labour in October 2011, of the

respondents that had had to renew insurance policies since 4 September 2010, 14.6% had experienced difficulty renewing existing policies.[79] Obtaining insurance on new and reconstructed buildings has been widely reported to be significantly more difficult than renewing an existing policy. Banks will not fund redevelopment of buildings in the absence of adequate insurance, including insurance against earthquakes.

Secondly, the high level of insurance and the fact that much of it is on a replacement basis, mean that many potential investors in the redevelopment of Christchurch have the funds to progress their aspect of the investment. The longer the delay the more likely they will decide to invest elsewhere.

Thirdly, New Zealanders are generally quite mobile and willing to shift residence and migrate overseas to places like Australia. Most New Zealanders are entitled to live and work in Australia without obtaining a visa. The slower the momentum of reconstruction in Christchurch the greater the number of residents who are likely to migrate to other parts of New Zealand or overseas.

Finally, the CBD of Christchurch has been in relative decline for a long period of time. This is an added barrier to stimulating investment in this part of Christchurch.

4.2. Regional

4.2.1. Regional Co-operation in Disaster Management

New Zealand's experience is that regional co-operation on search and rescue, maintaining security for people and property and victim identification in the period immediately after a major natural disaster is very worthwhile. Trained experts in these fields can provide much needed assistance. It is unlikely that even a medium sized country would have natural disasters frequent enough to warrant maintaining the number of people required for these tasks with the appropriate expertise.

Drawing on people with these skills on a regional basis, and sending local teams with these skills to assist in other countries in the region is a good means of maintaining high quality capacity and access to sufficient numbers on the relatively rare occasions they are required. Regional co-operation in setting standards and ensuring that personnel providing these specialist services have the required level of expertise and access to the necessary resourcing would also be desirable.

4.2.2. Disaster Insurance

New Zealand's experience with EQC and disaster insurance contains some lessons for others:

- high levels of disaster insurance properly backed by international reinsurance can go a long way to ameliorating the financial costs of a disaster;
- the provision of a national scheme, like New Zealand's EQC, encourages high levels of coverage by private parties;
- high penetration of insurance brings its own issues for the recovery task:
  - considerable resources are required to assess the numerous claims in a large event;
  - it increases the liquidity of the assets of persons affected by the disaster and this can stimulate migration to other regions rather than rebuilding the affected region; and
  - delays in re-establishing access to insurance can retard the recovery process.

References

Ansely, G. (2012), *NZ, Australia to Tighten Security Ties*. Otago Daily Times [online] 29 January. http://www.odt.co.nz/news/politics/196025/nz-australia-tighten-security-ties (last accessed 28 March 2012).

Auckland Council (n.d.), *Volcano Monitoring*. GNS Science.http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Alert-Nation/Volcano-Monitoring (last accessed 28 March 2012).

Bollard, A. and S. Ranchhod (2011), *Economic Impacts of Seismic Risk: Lessons for Wellington. Speech by Dr. Bollard to the Rotary Club of Wellington and Victoria University of Wellington."Organisational Effectiveness in Times of Seismic Risk" 18 October 2011*. http://www.rbnz.govt.nz/speeches/4559383.html (last accessed 28 March 2012).

Canterbury Earthquake Recovery Authority (n.d.), *Demolitions*. CERA [online]. http://cera.govt.nz/demolitions/list (last accessed 25 June 2012).

Chapple, S. (1997), 'The Economic Effects of the 1931 Hawkes Bay Earthquake', *NZIER Working Paper, No.* 97/7, Wellington: NZIER.

Christchurch City Libraries (n.d.), *New Zealand Disasters*. Christchurch: Christchurch City Council.

http://christchurchcitylibraries.com/kids/nzdisasters/abbotsford.asp (last accessed 28 March 2012).

Coronial Services of New Zealand (n.d.), *Media Updates from the Chief Coroner*, New Zealand: Ministry of Justice Home. http://www.justice.govt.nz/courts/coroners-court/christchurch-earthquake/media-updates-from-the-chief-coroner (last accessed 28 March 2012)

Crow C. (updated live), *Canterbury Quake Live*. Canterbury Quake Live.http://www.canterburyquakelive.co.nz/ (last accessed 25 June 2012).

Department of Labour (2011), *A Changing Landscape: the Impact of the Earthquakes on Christchurch Workplaces, December 2011*. Wellington: Department of Labour.

Flucount (n.d.) *Date Rate per Infection Table*. Flucount. http://www.flucount.org/ (last accessed 28 March 2012).

Geonet (n.d.)a., *Auckland Volcanic Field*, New Zealand: GeoNet. http://www.geonet.org.nz/volcano/our-volcanoes/auckland-volcanic-field.html (last accessed 28 March 2012).

Geonet (n.d.)b., *Earthquake*, New Zealand: GeoNet. http://www.geonet.org.nz/earthquake/ (last accessed 28 March 2012).

Geonet (n.d.)c., *GeoNet's Current Landslide Monitoring Projects and the Reports from Earlier Responses*, New Zealand: GeoNet. http://www.geonet.org.nz/landslide/ (last accessed 28 March 2012).

Geonet (n.d.)d., *Historic Earthquakes*, New Zealand: GeoNet. http://www.geonet.org.nz/earthquake/historic-earthquakes/ (last accessed 28 March 2012).

Geonet (n.d.)e., *Tsunami*, New Zealand: GeoNet. http://www.geonet.org.nz/tsunami/ (last accessed 28 March 2012).

GNS Science (n.d.)a., *Natural Hazards*. GNS Science. http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards (last accessed 28 March 2012)

GNS Science (n.d.)b., *Tsunami in New Zealand*. New Zealand: GNS Science. http://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/Earth-s-Forces/Tsunami/Tsunami-in-New-Zealand (last accessed 28 March 2012).

GNS Science (n.d.)c., *Volcano of Auckland*. GNS Science. http://www.arc.govt.nz/environment/volcanoes-of-auckland/monitoring.cfm (last accessed 28 March 2012).

Guy, H. N. (2011), *Last International USAR Team Leaves Christchurch*. Scoop Parliament [online] 17 March. Available at: http://www.scoop.co.nz/stories/PA1103/S00297/last-international-usar-team-leaves-christchurch.htm (last accessed 28 March 2012).

Hallegatte, S. and V. Przyluski (2010), 'The Economics of Natural Disasters: Concepts and Methods', *World Bank Policy Research Paper*, No. 5507, Washington D.C.: World Bank.

Hembery, O. (2011), *Kiwifruit Rivals Join Forces to Fight Psa*. NZherald, July 5, 2012. http://www.nzherald.co.nz/biosecurity/news/article.cfm?c_id=500816&objectid=10733447 (last accessed 28 March 2012).

Hickey, B. (2012), *RBNZ Governor Alan Bollard Says Bank Now Estimates ChCh quake Claims at NZ$30 bln and delays rebuild forecasts by "few months" to 2013.* Interez.co.nz [online] 27 January. http://www.interest.co.nz/news/57652/rbnz-governor-alan-bollard-says-bank-now-estimates-chch-quake-claims-nz30-bln-and-delays- (last accessed on 28 June 2012).

Keefer, P., E. Neuayer, and T. Plumper (2010), 'Earthquake Propensity and the Politics of Mortality Prevention', *World Bank Policy Research Working Paper*, No. 5182, Washington, D.C.: World Bank.

Loayza, N., E. Olaberria, J. Rigolini and L. Christiansen (2009), 'Natural Disasters and Growth: Going Beyond the Averages', *World Bank Policy Research Working Paper*, No. 4980, Washington D.C.: World Bank.

Lopez, R. (2009),'Natural Disasters and the Dynamics of Intangible Assets', *World Bank Policy Research Working Paper*, No. 4874, Washington, D.C.: World Bank.

Lynch, K., N. Mathewson and D. Williams (n.d.), *Quake Toll Lifted to 184*. New Zealand: Fairfax NZ News. http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6365058/Quake-toll-lifted-to-184 (last accessed 28 March 2012)

Mann, C. and N. Mathewson (2012), *New Riverside Red Zone*. Fairfax NZ News [online] 23 March. Availabe at: http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6624862/New-riverside-red-zone (last accessed 28 March 2012).

Mcsaveney, E. (2012), 'Historic Earthquakes', Te Ara – the Encyclopedia of New Zealand. http://www.teara.govt.nz/en/historic-earthquakes/ (last accessed 28 March 2012).

Melecky, M. and C. Raddatz (2010), 'How Do Governments Respond After Catastrophes? Natural-Disaster Shocks and the Fiscal Stance', *World Bank Policy Research Working Paper*, No. 5564, Washington D.C.: World Bank.

Ministry for Primary Industries (n.d.)a., *Gypsy Moth*. New Zealand Government http://www.biosecurity.govt.nz/pests/gypsy-moth (last accessed 28 March 2012).

Ministry for Primary Industries (n.d.)b., *Kiwifruit Vine Disease*. New Zealand Government. http://www.biosecurity.govt.nz/pests/kiwifruit-vine-disease (last accessed 28 March 2012).

Ministry for Primary Industries (n.d.)c., *Painted Apple Moth*. New Zealand Government. http://www.biosecurity.govt.nz/pests/painted-apple-moth (last accessed 28 March 2012).

Morse, K. (2008), 'NZ's Tsunami Monitoring Network', *Wild Land blog* [blog] 18 February. Available at: http://wildland.owdjim.gen.nz/?p=568 (last accessed 28 March 2012)

New Zealand History online (n.d.)a., *New Zealand Disaster Timeline*, New Zealand: Ministry for Culture and Heritage. http://www.nzhistory.net.nz/culture/new-zealand-disasters/timeline (last accessed 28 March 2012).

New Zealand History online (n.d.)b., *The 1918 Flu Pandemic*, New Zealand: Ministry for Culture and Heritage. http://www.nzhistory.net.nz/culture/influenza-pandemic-1918 (last accessed 28 March 2012).

New Zealand Police (2011), *Police Pay Tribute to Australian Contingent leaving Christchurch.* New Zealand Police [online] 10 March. Available at: http://www.police.govt.nz/news/release/27404.html (last accessed 28 March 2012).

NZarmy (2011), *Singapore Armed Forces Assistance Appreciated*. New Zealand army [online] 15 March. Available at: http://www.army.mil.nz/at-a-glance/news/media-releases/media-release.htm@guid=%7Bfab412fa-01a3-40f0-b8ea-dcfa9fbe9060%7D.htm (last accessed 28 March 2012).

NZIER (2011), Canterbury After the Earthquakes, November 2011. Wellington: NZIER.

Okazaki, T., K. Ito and A. Imaizumi (2011), 'Impact of Natural disasters on Industrial Agglomeration: the Case of the 1923 Great Kanto Earthquake', *CIRJE Discussion Paper*, Tokyo: CIRJE available at: http://www.cirje.e.u-tokyo.ac.jp/research/03research02dp.html. (last accessed 28 March 2012).

One News (2011a), *Chch Quake Cost could hit $30 billion*, One News [Online] 25 October. Available at: http://tvnz.co.nz/national-news/christchurch-quake-cost-could-hit-30-billion-4482971 (accessed 28 March 2012).

One news (2011b), *Thousands Return to Quake-devastated Mall.* One News [on line] 29 October. Available at: http://tvnz.co.nz/national-news/thousands-return-quake-devastated-mall-4488717 (last accessed 28 March 2012).

Raddatz, C. (2009), 'The Wrath of God: Macroeconomic Costs and Natural Disasters', *World Bank Policy Research Working Paper*, No. 5039, Washington, D.C.: World Bank;

Recovery Canterbury (2011), *Further 758 Christchurch Properties Rezoned*. Recovery Canterbury [online] 17 November. Available at: http://www.recovercanterbury.co.nz/news/126/further-758-christchurch-properties-rezoned.aspx (last accessed 28 March 2012)

Sharpe, M. (2011), *What Napier Can Teach Christchurch about Earthquake Recovery*. Fairfax NZ News [online] 26 March. Available at:

http://www.stuff.co.nz/dominion-post/news/4811992/What-Napier-can-teach-Christchurch-about-earthquake-recovery (last accessed 28 March 2012).

Simon Chapple (1997), 'The Economic Effects of the 1931 Hawkes Bay Earthquake', *NZIER Working Paper, No.* 97/7, Wellington: NZIER, p.27.

Statistics New Zealand (2011a), *Household Labour Force Survey*, December 2011. Wellington: Statistics New Zealand.

Statistics New Zealand (2011b), *Sub-national Population Estimates: 30 June 2011*. Wellington: Statistics New Zealand. See http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalPopulationEstimates_HOTPJun11.aspx (last accessed 28 March 2012).

Stylianou, G. (n.d.), *Woman's Death Lifts Earthquake Toll to 185*, New Zealand: Fairfax NZ News. http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6395047/Womans-death-lifts-earthquake-toll-to-185 (last accessed 28 March 2012).

The Breeze (n.d.), *Christchurch Business Relocation Directory*. The Breeze [online]. http://www.thebreeze.co.nz/Regions/Christchurch/RelocationDirectory/tabid/578/Default.aspx (last accessed 10 July 2012).

The Weather Network (n.d.), *Glossary: Weather Bomb*. The Weather Network. http://www.theweathernetwork.com/glossary/weatherbomb (last accessed 28 March 2012).

Wellington City Library (n.d.), *Heritage > Earthquakes*, Wellington: Wellington City Library. http://www.wcl.govt.nz/heritage/earthquakes.html (last accessed 28 March 2012).

Wikipedia (n.d.)a., *1931 Hawke's Bay Earthwuake.* Wikipedia [online] http://en.wikipedia.org/wiki/1931_Hawke%27s_Bay_earthquake (last accessed 28 March 2012).

Wikipedia (n.d.)b., *2011 Christchurch Earthquake*. Wikipedia [online]. http://en.wikipedia.org/wiki/2011_Christchurch_earthquake (last accessed 28 March 2012).

Wikipedia (n.d.)c., *Cyclone Bola*. Wikipedia [online]. http://en.wikipedia.org/wiki/Cyclone_Bola (last accessed 28 March 2012).

Wikipedia (n.d.)d., *Varroa Destructor*. Wikipedia [online] http://en.wikipedia.org/wiki/Varroa_destructor (last accessed 28 March 2012).

Wood, A. (n.d.), *February Quake 'Third Most Expensive'*. Fairfax NZ News [online]. Available at: http://www.stuff.co.nz/business/rebuilding-christchurch/6663626/February-quake-third-most-expensive (last accessed 28 March 2012).

World Health Organization (n.d.), *SARS Cases Worldwide*. USA Today [flash data. http://www.usatoday.com/news/health/sarscases/flash.htm (last accessed 28 March 2012)

Appendix I: Table 3 – Estimated Costs

Direct Costs

Households

Dwellings

The replacement cost figure has been estimated by adding to the estimated EQC claims for dwellings (http://canterbury.eqc.govt.nz/news/progress/statistics(last accessed 28 March 2012)and Appendix II) the estimated value of red-zoned residential buildings calculated as the estimated number of dwellings that will be red-zoned (8,206) times $NZ150,000 per dwelling plus allowance for dwelling costs over EQC limit of $NZ100,000 per dwelling (assumed to be 25,000 dwellings at $NZ35,000 on average). Adjusted by assuming that 95% of the dwellings subject to loss were covered by EQC. The depreciated replacement cost figure has been derived from the replacement cost figure by assuming that on average the houses requiring replacement were 33% depreciated. Many of the residential red-zoned buildings and others suffering severe damage, such as those on the Port Hills, are in relatively recently developed areas of the city; the assumed depreciation rate of 33% reflects this.

Value of Residential Land Losses

Estimated value of claims for land to EQC ($NZ27.0 million) plus estimated market value of residential land red-zoned under the Government's compulsory purchase scheme. The former figure is based on pro-rata scaling of EQC resolved claims data as at 22 March 2012 (http://canterbury.eqc.govt.nz/news/progress/statistics(last accessed 28 March 2012)and Appendix II). The latter figure is derived by adjusting the Government's 2012/13 budget estimates of the costs for the purchase, management and demolition of residential red-zone land and associated legal costs. The adjustment has been made to reflect the number of additional properties likely to be red-zoned (1,206) after 22 March 2011 and estimates of the likely market value of each of these properties. The figure has been adjusted by assuming that 95% of the dwellings subject to loss were insured and covered by EQC and the Government compulsory purchase scheme. Further assumptions are that the cost of demolition of each additional red-zoned house will be on average $NZ10,000 and the value of the land once vacant will be on average $NZ10,000 per hectare and there were on average 15 houses per hectare. The estimates are on a replacement cost basis as land does not depreciate.

House Contents and Personal Property

The replacement cost figure has been derived from an estimate of the claims for house contents and personal property to EQC based on pro rata scaling of data as at 22 March 2012 (see http://canterbury.eqc.govt.nz/news/progress/statistics (last accessed 28 March 2012) and Appendix II). Adjusted by assuming that 30% of the claims will be over the EQC limit of $NZ20,000 by on average $NZ10,000 each. Further adjusted by assuming that 90% of the house contents and personal property subject to loss was covered by EQC and assuming that 75% were insured

on a replacement cost basis and 25% on an indemnity basis and that the latter was on average 50% of the replacement cost. The depreciated replacement cost figure has been derived from the replacement cost figure by assuming that on average the assets requiring replacement were 50% depreciated.

Motor Vehicles

The replacement cost figure has been estimated by assuming that 500 motor vehicles were damaged at an average replacement or repair cost of $NZ10,000 each and that 80% of them were private vehicles belonging to households and 20% were commercial and industrial vehicles. Since there is a good second hand market for vehicles the costs of replacement will not be the new cost of the vehicles but the cost of replacing like with like.

Accident and Emergency Medical Treatment

From Government Financial Statements to 30 June 2011 plus $NZ2 million additional cost to cover expenses incurred after 30 June 2011.

Commercial and Industrial (C&I)

Buildings

The rateable value(i.e. value of improvements for the purpose of levying local property taxes or estimated market value)in Christchurch City as at 1 July 2010 was $NZ41.747 billion. The rateable value of improvements inside the CBD area was $NZ3.370 billion and the rateable value of improvements in the area in the CBD cordoned off following earthquake on 22 Feb 2011 was $NZ1.071 billion (Source Christchurch City Council). We have assumed 95% of the cordoned area's value of improvements is commercial and 90% of the balance of CBD's rateable value of improvements is commercial and 20% of balance of city's rateable value of improvements is commercial. Moreover, we assume the loss of commercial rateable value of improvements in the cordon area was 80% and in the balance of CBD area it was 50% and 20% in the balance of the city. From these estimates we deduct the estimated commercial rateable value of improvements lost that are included elsewhere in the table - ports, airports, local and central government buildings, solid waste disposal and 5% of electricity transmission and distribution and telecommunications networks.

The replacement cost figure has been derived from this estimate, which is essentially a depreciated replacement cost estimate, by assuming that on average the assets requiring replacement were 67% depreciated. This high depreciation rate reflects the high average age of the buildings destroyed and damaged in the CBD and other commercial areas. Most modern buildings withstood the earthquakes better than the older buildings.

As at 24 June 2012, 798 commercial and industrial buildings had been issued with official notices requiring demolition, 99 had been issued with notices requiring them to be "made safe' and 208 with notices requiring their partial demolition (see http://cera.govt.nz/demolitions/list(last accessed on 24 June 2012)). This leads to a total of 1,105 buildings. The number of buildings subject to such orders was still increasing at that date. Assuming the final total increases to 1,200 buildings, the

average loss per building is $NZ2.56 million. When demolition costs are taken into account this figure appears reasonable as an average.

Value of Residential Red-zoned Former Commercial and Industrial Land

Very little commercial or industrial land is in the area that is being abandoned for geo-technical reasons. The estimate of $NZ3.0 million is to cover small shopping areas that will be abandoned when the residents depart.

Plant, Machinery and Equipment

Assumed to average $NZ7,500 replacement cost for each of the 48,211 enterprises reported by Statistics New Zealand as operating in June 2010 in the three territorial local authority areas most affected by the quakes: Selwyn and Waimakariri Districts and Christchurch City. The depreciated replacement cost estimate has been derived from this figure by assuming that on average the assets requiring replacement were 50% depreciated.

Motor Vehicles

As noted in relation to household costs above, the replacement cost figure has been estimated by assuming that 500 motor vehicles were damaged at an average replacement or repair cost of $NZ10,000 each and that 80% of them were private vehicles belonging to households and 20% were commercial and industrial vehicles. Since there is a good second hand market for vehicles the costs of replacement will not be the new cost of the vehicles but the cost of replacing like with like.

Stocks

Calculated by multiplying the share of New Zealand enterprises in the 3 territorial local authorities most severely affected by the earthquake (9.55%) times total wholesale and retail stocks in New Zealand as at 31 December 2010 ($NZ14.6 billion) and assuming a 50% loss factor. The high loss factor includes an allowance for there being several earthquakes strong enough to damage stocks.

Infrastructure

Roads – Local and State Highway

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Electricity Distribution Network

See http://www.scoop.co.nz/stories/AK1112/S00553/ independent-report-on-orions-earthquake-response.htm (last accessed on 28 March 2012). Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Electricity Transmission Network

See http://www.transpower.co.nz/n4666.html (last accessed on 28 March 2012). Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Gas Distribution Network

There are only very small local distribution networks in Christchurch and these are on the side of the city not severely affected by the earthquakes.

Sewage System

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Storm-Water Systems

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Water Supplies

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Solid Waste Disposal Systems

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Telecommunications Networks

Replacement cost estimate based on data provided in media statements and/or annual reports of four major telecommunications providers in New Zealand. Telecom $NZ35.0 million = $NZ42.0 million - $NZ7.0 million from annual report http://media.corporate-ir.net/media_files/IROL/91/91956/Annual_Report_NZ.pdf (last accessed on 28 March 2012) plus $NZ32.0 million*.5 = $NZ.016 million for Telstra Clear (see http://www.telstraclear.co.nz/company-info/media-release-template.cfm? newsid=420 (last accessed on 28 March 2012)) plus $NZ5.0 million for Vodafone (network remained operational) and $NZ1.0 million for 2degrees whose network was largely unaffected. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 40% depreciated.

Port Assets

According to the port company the adjustment to asset values to reflect the damage was $NZ29 million.
http://www.lpc.co.nz/TempFiles/TempDocuments/2011%20Media%20Releases/NZX%20Release%20LPC%20Result%20for%20Year%20End%2030%20June%202011%20FINAL%2025%20August%202011.pdf (last accessed on 29 March 2012). The accounts of the company record assets at depreciated replacement cost. To derive the replacement cost value of assets it has been assumed that the assets requiring replacement were 75% depreciated. This

high figure reflects the very old age of much of the fixed infra- structure – wharves, etc. – at the port.

Airport Assets

See http://www.stuff.co.nz/business/5732964/Quakes-hit-CIAL-revenue (last accessed on 28 March 2012). It is assumed that all the expenditure is on restoration and repair and that none will be capitalised so that the depreciated replacement cost and replacement cost are one and the same.

Local Government

Buildings

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 67% depreciated.

Sports Facilities, Parks and Reserves

Replacement cost estimate obtained from *Stronger Christchurch Infrastructure Rebuild Plan*, Dec 2011, p.16. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 50% depreciated.

Central Government

Buildings

Budget Economic and Fiscal Update 2011, p.98. Depreciated replacement cost estimate derived by assuming the assets requiring replacement were 50% depreciated.

Value of Red-zoned former Government Land

Very little red-zone land held by government. Notional figure to cover loss of value in land under schools.

Other

Notional figure to cover plant, equipment, etc. losses.

Indirect Costs

Production

GDP Lost in Canterbury

Based on mid-point of NZIER's estimate of a 5-7% drop in Canterbury's GDP in 2011. Assumed that loss in GDP is recaptured linearly over a 4 year period. $NZ3,287 million is the present value of the loss of GDP at a 10% discount rate.

GDP Gains in Rest of New Zealand

Assumed to be 25% of the loss of GDP in Canterbury.

Additional travel costs

Schools

Estimated that on average 10,000 pupils were shifted to a new school location five days a week for 26 weeks on average at an estimated average daily cost of $NZ5.

Other Intra-regional

Notional estimate of $NZ5.0 million to cover increased time and distance required to travel in the region due to the poor quality of some roads as a result of damage and the disruption to the road system.

Other Extra-regional

Notional estimate of $NZ5.0 million to cover increased inter-regional travel as relatives take extra trips to visit relatives and friends in the city and residents take extra trips to escape the damaged zone.

Temporary relocation costs

Households

An estimated 30,000 moves at an average $NZ10,000 per move.

Other

Temporary relocation of 10% of the 48,211 enterprises in the three most heavily affected territorial local authorities at an estimates cost of $NZ10,000

Value of Land Reclaimed at Lyttelton

Lyttelton Port Company Ltd obtained approval to use waste rubble from the demolition of buildings to reclaim 10 hectares of land from the harbour at Te Awaparahi Bay. In part, this permission is reflected in lower costs of disposal of waste; the annual report of the company estimates this to be in excess of $100 million. This aspect should be captured in the other cost estimates. It is also resulting in an additional 10 hectares of land adjacent to the port without the need to quarry rock. The economic value of this land is the present value of the future increment in free cash flows it will generate. A figure of $NZ2.0 million would appear a generous estimate of the annual average increase in free cash flow. Hence, our additional figure for this item is $NZ20.0 million. Since this is a benefit it is recorded as a negative cost in the table.

Cost of Temporary Replacement for AMI Stadium

The government paid $NZ28.0 million to provide Christchurch with a temporary replacement for its main sports arena, AMI Stadium. See Government's 2012/13 budget estimates showing the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

APPENDIX II: Table 4 – Contributions to Replacement Costs

Insurance and Reinsurance (excluding EQC and AMI and ACC)

Late in 2011 Swiss Re, a re-insurance provider, estimated the insurance costs of the 4 September 2010 and 22 February 2011 earthquakes at $US17.0billion. To take account of additional damage in the June and December 2011 quakes, and business continuity costs being greater than probably expected at the time Swiss Re made its estimate, we have moved the figure up to $US19.0 billion. This has been converted to $NZ at an exchange rate of $NZ1.00 equal to 0.785 US cents, the approximate rate around the time of Swiss Re's press release. This figure has been adjusted down for payments by EQC and the Government's support for AMI, the New Zealand-based insurer that failed as a result of the quakes.

EQC (Including $NZ4.2billion sum reinsured and Government's contribution)

Houses

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

Contents and Personal Property

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

Residential Land

Calculated by scaling up on a pro rata basis the claims resolved by EQC as at 22 March 2012 http://canterbury.eqc.govt.nz/news/progress/statistics.

ACC Insurance Payments for Treatment of Injuries etc.

Government Financial Statements for June 2011, p.128 ($NZ7.0million) plus $NZ2.0million for post 30 June 2011 costs.

Total Contribution from Insurers

Sum of previous items.

Government (excluding EQC)

Financial Support to AMI:

Estimate taken from Treasury statements reported in *http://www.scoop.co.nz/stories/PA1204/S00072/govt-welcomes-completion-of-ami-sale.htm(5 April 2012)* (accessed on 24 June 2012)

Repair and Replacement of State-owned Assets

Government Financial Statements for June 2011, p.128.

Contribution towards Repair and Replacement of Local Government-owned Assets

75% of estimated costs of repair and replacement of local roads and state highways as per Appendix I and Table 3. The standard government contribution is 50% for local roads and 100% for state highways; plus $NZ28.0 million paid by

the Government to construct a temporary replacement for AMI Stadium; plus $NZ24.34 million contribution to advanced payment for the estimatedcentral government share of the Stronger Infrastructure Rebuild Team's infrastructure costs. The latter two figures are contained in the Government's 2012/13 budget estimates showing the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

Purchase of Residential Red-zone Land and Related Costs

Derived from Government's 2012/13 budget estimates of the costs for the purchase and management of residential red-zone land and associated legal costs in the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

Demolition of CBD Properties

Derived from Government's 2012/13 budget estimates in the Financial Forecast Statements for the Canterbury Earthquake Recovery Authority p.32.

Payments to Local Government for Response and Recovery Costs

Derived from the Government's 2012/13 budget estimates in the Information Supporting the Supplementary Estimates: Vote Emergency Management, p. 293.

Other Earthquake Related Expenses

Residual item between sum of items above and *Total contribution from central government*.

Total Contribution from Central Government

Total from: Government Budget 2012/13 Performance Information for Appropriations: Vote Canterbury Earthquake Recovery, p. 31; plus estimates of *Financial support for AMI*; plus *Repair and replacement of state-owned assets*; plus *Contribution towards repair and replacement of local authority assets* (excluding to avoid double counting replacement of AMI stadium and advanced payment for Crown's share of infrastructure costs); plus *Payment to local government for response and recovery costs*; plus 20% of households' loss of income assumed to be covered by social welfare payments and special grants, etc.

Private Charity

Organised

See http://www.stuff.co.nz/the-press/news/christchurch-earthquake-2011/6243606/200-million-donated-for-quake-relief (last accessed on 28 March 2012).

Families and Friends

Estimated as an average $100 per household for 200,000 households.

Households

Asset Losses

Losses of dwellings, land and household and personal property not covered by insurance. It is assumed that 5% of dwellings and land losses fall in this category and 10% of household and personal property losses.

Loss of Income

80% *of* 65% of the net loss of GDP. 65% represents approximately the share of labor in GDP. 80% is the share borne by households; the balance is estimated to be borne by the Government (as increased social welfare).

Temporary Relocation Costs

90% of the total relocation costs of households as estimated in Table 3 (see Appendix I). 10% of the costs are estimated to be borne by insurance companies.

Commercial and Industrial Businesses

Asset Losses

Losses of buildings, land, plant machinery and equipment, motor vehicles, stocks, electricity distribution and transmission, telecommunications networks, port and airport assets not covered by insurance. Assumed to be between 2% and 10% depending on the asset class. The figure is adjusted for the $20 million increase in the value of land at the port as a result of reclamation.

Loss of Profits

70% of 35% of the net loss of GDP. 35% represents approximately the share of capital and 70% the share borne by the owners of businesses. The balance is estimated to be borne by insurers.

Temporary Relocation Costs

Half the assumed total temporary relocation costs of businesses. The other half is estimated to be borne by insurance companies.

Local Government

Asset losses relating to local government assets not covered by insurance or central government contributions. Estimated to be 33.3% of the replacement value of the assets. The evidence is that local government was materially underinsured on a replacement cost basis.

Discrepancy

Balancing item so that total contributions to losses at replacement cost in Table 4 equal the estimated total losses at replacement cost in Table 3.

Total Contributions to Losses at Replacement Cost

Sum of the components in the table.

ENDNOTES

[1] The shortest distance between Australian and New Zealand territory is the 617km between the Auckland Islands (New Zealand) and Macquarie Island (Australia) in the Southern Ocean, well away from the major land masses and population centres of both countries.
[2] Geonet (n.d.)a.
[3] New Zealand History online (n.d.)a.
[4] Wellington City Library (n.d.)
[5] Geonet (n.d.)d.
[6] Coronial Services of New Zealand (n.d.). The initial toll was 181 dead but subsequently the coroner (the official investigator into the causes of death) has classified 4 additional deaths as directly attributable to the 22 February 2011 earthquake. See Lynch and Williams (n.d.) and Stylianou (n.d.)
[7] GNS Science (n.d.)b.
[8] Ministry for Primary Industries (n.d.)c.
[9] Ministry for Primary Industries (n.d.)a.
[10] Wikipedia (n.d.)d.
[11] Ministry for Primary Industries (n.d.)b.
[12] Hembery (2011)
[13] New Zealand History online (n.d.)b.
[14] According to World Health Organization (n.d.) there was one death from SARS recorded in the country.
[15] Flucount (n.d.)
[16] The Weather Network (n.d.)
[17] New Zealand History online (n.d.)a.
[18] Wikipedia (n.d.)c.
[19] Christchurch City Libraries (n.d.)
[20] New Zealand History online (n.d.)a.
[21] GNS Science (n.d.)a.
[22] Auckland Council (n.d.)
[23] GNS Science (n.d.)c.
[24] Geonet (n.d.)b.
[25] Geonet (n.d.)e.
[26] Morse (2008)
[27] http://www.metservice.com/national/index (last accessed 28 March 2012).
[28] http://www.niwa.co.nz/our-science/climate (last accessed 28 March 2012).
[29] Geonet (n.d.)c.
[30] http://www.geonet.org.nz/ (last accessed 28 March 2012).
[31] http://www.civildefence.govt.nz/ (last accessed 28 March 2012).
[32] Guy (2011)
[33] New Zealand Police (2011)
[34] NZarmy (2011)
[35] Wikipedia (n.d.)b.
[36] Ansely (2012)
[37] Wikipedia (n.d.)a.
[38] Chapple (1997: 27)
[39] Sharpe (2011)
[40] http://cera.govt.nz/ (last accessed 28 March 2012).
[41] http://cera.govt.nz/demolitions/list (last accessed 25 June 2012).
[42] Wikipedia (n.d.)b.
[43] Recovery Canterbury (2011) and Mann and Mathewson (2012).

[44] Lopez, R. (2009); Loayza, *et al.* (2009); Raddatz, (2009); Keefer, *et al.* (2010); Melecky and Raddatz (2010)
[45] Hallegatte and Przyluski (2010)
[46] *Ibid.*, p.2.
[47] *Ibid.*, pp.2-3.
[48] Hallegatte and Przyluski (2010), p.4.
[49] *Ibid.*, pp.4-5.
[50] Calculated from Reserve Bank data published in http://www.rbnz.govt.nz/statistics/exandint/b1/index.html (last accessed on 10 July 2012).
[51] It is likely that damaged motor vehicles will be replaced by second-hand vehicles of similar quality and age. This means the actual replacement cost will be the depreciated replacement cost for motor vehicles and two separate estimates are not required.
[52] Bollard and Ranchhod (2011)
[53] Hickey (2012)
[54] Wood (n.d.)
[55] One News (2011a)
[56] *Ibid.*
[57] Statistics New Zealand (2011b)
[58] *Ibid.*
[59] Statistics New Zealand (2011b)
[60] NZIER (2011)
[61] *Ibid.*
[62] *Ibid.*
[63] *Ibid.*
[64] *Ibid.*
[65] *Ibid.*
[66] Bollard and Ranchhod (2011)
[67] *Ibid.*
[68] The Breeze (n.d.)
[69] The terms "lawyer" and "solicitor" are used interchangeably in New Zealand. "Barristers" are lawyers who only represent clients in Court and do not undertake other legal functions. "Barristers and solicitors" are lawyers who undertake both Court and non-Court legal work.
[70] Also includes addresses described as in Strowan.
[71] Department of Labour (2011)
[72] One News (2011b)
[73] The work is known as the Broadmoor Project. See http://belfercenter.ksg.harvard.edu/project/54/broadmoor_project.html (last accessed 28 March 2012).
[74] See Douglas Ahlers' slide presentation to a public meeting in Christchurch entitled 'Disaster recovery: what the research shows', August 2011. Available at: http://futurechristchurch.wordpress.com/2011/10/11/douglas-ahlers/ (last accessed 28 March 2012).
[75] Okazaki, *et al.* (2011).
[76] *Ibid.*, p.10.
[77] http://www.eqc.govt.nz/(last accessed 28 March 2012).
[78] http://www.nasdaq.com/aspx/stock-market-news story.aspx?storyid=201112081942dowjonesdjonline000649&title=new-zealand-november-median-house-price-nz367500-up-24on-october-reinz (last accessed 28 March 2012). This includes the value of the land upon which the house stands.
[79] Department of Labour (2011: 16), Table A11.

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