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Insuring Earthquakes: How Would the Californian and Japanese Insurance Programs Have Fared Down Under (after the 2011 New Zealand Earthquake)?

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Abstract: Earthquakes are insured only with public sector involvement in high-income countries where the risk of earthquakes is perceived to be high. The proto-typical examples of this public sector involvement are the public earthquake insurance schemes in California, Japan, and New Zealand (NZ). Each of these insurance programs is structured differently, and the purpose of this paper is to examine these differences using a concrete case-study, the sequence of earthquakes that occurred in the Christchurch, New Zealand, in 2011. This event turned out to have been the most heavily insured earthquake event in history. We examine what would have been the outcome of the earthquakes had the system of insurance in NZ been different. In particular, we focus on the public earthquake insurance programs in California (the California Earthquake Authority - CEA), and in Japan (Japanese Earthquake Reinsurance - JER). Overall, the aggregate cost to the public insurer in NZ was $NZ 11.1 billion in its response to the earthquakes. If a similar-sized disaster event had occurred in Japan and California, homeowners would have received $NZ 2.5 billion and $NZ 1.4 billion from the JER and CEA, respectively. We further describe the spatial and distributive patterns of these different scenarios.

*Corresponding Author. We thank participants of a workshop held in Wellington in October 2016 for planting the idea for this paper. We also thank QuakeCore and the NZ Resilience National Science Challenge for providing funding that supported this work.

1. Introduction

Globally, earthquakes can occur almost anywhere, but the risk of earthquakes damaging man-made assets is much higher in some specific regions. This risk is especially acute around the Pacific Rim (on both sides of the Ocean), the Alpide belt which stretches across the entire Mediterranean from Portugal to the Middle East, and on to the Himalayas, and the Western edge of Indonesia. Other regions, like some areas in the South Pacific, the Rift Valley in North-Eastern Africa, or the Caribbean can also experience severe events (e.g., the 2010 catastrophic earthquake in Haiti). In poorer countries, insurance is very rare and is typically purchased only by very wealthy households and larger businesses. In most high-income countries where the risks of earthquakes is relatively low, private insurers include earthquake peril in their coverage (e.g., Israel). However, in high-income countries where the risk of earthquakes is perceived to be high, private insurers are generally very reluctant to offer earthquake cover without some government support. The proto-typical examples of this public sector involvement in earthquake insurance markets are the public earthquake insurance schemes in California, Japan, and New Zealand.[1]

Each of these public insurance programs is structured differently, and the purpose of this paper is to examine these differences using a concrete case-study, the sequence of earthquakes that occurred in the Canterbury region of the South Island of New Zealand in 2010-2011.

The Canterbury earthquake sequence started in September 2010 with a damaging earthquake centred not far from the port of Littleton – a port that serves the city of Christchurch (population about 400,000, the biggest urban hub in the South Island). However, while there was significant damage from this earthquake, there were very few injuries, and the damage to residential housing was also limited. In February 2011, a strong and shallow earthquake occurred very close to the Central Business District of Christchurch, and damaged much of the city. Tragically, two office buildings collapsed and overall 185 people died. Most residential housing in the region experienced some damage, and maybe 90% of the public, commercial

[1] Other high-risk high-income regions do not yet have very well developed earthquake insurance markets (e.g., Oregon and Washington States in the US, British Columbia in Canada, Italy, and Greece). Turkey, a high-middle-income country facing high earthquake risk is unique in developing a large scale publicly-supported insurance scheme.

and office buildings in the centre of the city were damaged and had to be fixed (or demolished) before they could be occupied again.

The aftermath of the earthquake was challenging for insurers, as it turned out to have been the most heavily insured earthquake event in history, with practically almost all residential housing having insurance, and a large number of commercial and office buildings having coverage as well. In addition, the main public insurer was re-insured internationally.

Our purpose in this paper is to examine what would have been the outcome of the earthquake sequence had the system of insurance in NZ been different. In particular, we focus on two examples: the publically-supported earthquake insurance program in California (the California Earthquake Authority), and the public program in Japan (Japanese Earthquake Reinsurance). These are the two most widely known public earthquake insurance schemes, and our purpose in this paper is to analyse the deficiencies of both these programs – deficiencies that yield a much lower take-up rates (see Noy et al. (2017) , for a comparison of natural hazards public insurance schemes).

2. Earthquake Residential Insurance Scheme

2.1. New Zealand Earthquake Commission (EQC)

New Zealand is seismologically very active. There are 15,000 earthquakes in New Zealand every year, although most are not strong enough to be felt. Following two major earthquakes in 1931 and 1942, the Earthquake and War Damage Commission was establishes in 1945. It was established as a State Owned Entity owned by New Zealand Government and managed by a board of commissioners. It became the Earthquake Commission (EQC) in the 1993 EQC Act, the last time the law was revised.

EQCover is the seismic insurance cover provided by the EQC. It provides capped insurance to residential buildings, land and personal contents against the risk of earthquakes, volcanic eruptions, landslips, hydrothermal activity and tsunamis. It only covers residential properties and the land on which they are sited; commercial, industrial, and agricultural properties are only covered by private insurers. The EQCover insurance is a de-facto compulsory addendum to standard fire insurance policies (that are typically required by lenders for home loans).

Homes without standard fire insurance are not covered by EQCover, but in practice more than 90% of residential properties in New Zealand have it.

The EQCover has strict caps on both structural and contents cover, but anything above the cap is insured by the private insurer; the same insurer that issued the fire insurance policy through which the EQCover premiums are collected. Uniquely, EQCover also insures the land beneath the residential properties.[2] The deductible excess is much lower than other international schemes. The EQC buys reinsurance internationally, and also purchases annually a government full 'last resort' guarantee. Any collected premiums that are not used annually are accumulated and transferred to a Natural Disaster Fund (NDF). By 2011, the NDF had accumulated almost $NZ6 billion.

In the aftermath of the February 2011 catastrophic earthquake, the cost of reconstruction was forecasted to be very high, and even though the EQC had about $NZ 4 billion in re-insurance coverage, it also had to use practically all of the $NZ6 billion that previously accumulated in the NDF over the last few decades.

The EQCover has a flat premium rate irrespective of evaluated risk, and it is significantly more affordable than other international earthquake insurance schemes. Coverage costs 0.15 per cent of cover.[3] Maybe not coincidently, New Zealand also has one of the highest take-up rates of residential insurance cover for natural disasters in the world. In the above-mentioned 2011 Christchurch earthquake, practically all residential damages were covered by insurance.

2.2. Japanese Earthquake Reinsurance (JER)

Following the 1964 Niigata Earthquake[4], in 1966, the Japanese Earthquake Reinsurance (JER) scheme was created by the Government of Japan, which undertook the provision of reinsurance for earthquake risk. JER offers coverage on residential buildings and their contents. The coverage per insurance policy varies between 30 and 50 per cent of the

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[2] The insured amount is the lower value of either the damaged land's market value or the cost to repair the land to its pre-event condition. This proved to be a contentious issue in cases where the 2011 earthquake caused liquefaction.

[3] The cost was tripled from 0.05 per cent after international reinsurers increased their premiums in the aftermath of the 2011 earthquake.

[4] The Niigata Earthquake (M 7.5) happened on June 16, 1964, and damaged nine prefectures. The earthquake, ground liquefaction and flooding caused significant damages to infrastructures and residential properties in the region.

property value, while the claim payment is dependent on the degree of loss. Legally, the earthquake damage on property and content is classified by three levels: total loss, half loss and partial loss. The maximum insured amount is set to ¥JP 50 million per residential unit and ¥JP 10 million for content for a single earthquake event. The deductible fee (excess) equals the annual premium paid by policyholder with a set maximum amount.

The JER scheme was at first compulsory but has later become optional (in 1979). Private insurers must enrol in the JER scheme which offer optional earthquake insurance as part of a comprehensive fire insurance policy. As in the New Zealand case, the earthquake insurance premiums paid by policyholders are passed-on from the private insurer and managed by the government and the JER system. The maximum liability of the government, JER and private insurance are 87 per cent, 10 per cent and 3 per cent, respectively.

JER sets the annual basic premium rate for every ¥JP 1,000 of amount insured. The premium rate varies across zones, classified by their seismic exposure and building structures. The premiums paid by homeowners are between 0.05 per cent (risk zone 1 and wooden) and 0.35 per cent (risk zone 4 and non-wooden).

The Tohoku earthquake in 2011 was the costliest earthquake in history. Marsh (2014) reports that the earthquake caused an economics loss of $US210 billion of which only about $US35.7 billion was insured. This devastating disaster wiped out half of the JER program reserves and reduced its capacity significantly (Paudel, 2012). The epicentre of 2011 Tohoku earthquake was located in risk zone 1 which was thought to be associated with the lowest earthquake risk.[5] Even after the 2011 catastrophe, the penetration rate for the JER scheme is not very high; according to 2015 Japan's market report, it is increasing but still below 30 per cent.

2.3. California Earthquake Authority (CEA)

As is true for New Zealand and Japan, California is also very exposed to earthquakes. In 1985, California policymakers required that insurers offer earthquake insurance coverage to dwellings with one- to four-units. The Northridge earthquake of 1994, damaged more than 40,000 buildings, and caused total losses of $US21.7 billion to insurers[6] (Kunreuther & Michel-

[5] This is not unusual. The Christchurch earthquake in New Zealand and the Northridge earthquake in California, both happened in areas that were considered to have relatively lower risk of earthquakes.

[6] The residential insured losses exceeded $12 billion (Marshall, 2017).

Kerjan, 2014). This created a surge in demand for earthquake insurance. However, Kunreuther and Roth (1998) maintain that after paying claims and re-evaluating earthquake exposures, private insurers decided to reduce their earthquake risk underwriting and had placed restricting terms on remaining polices. As a result, the California Earthquake Authority (CEA) was established in 1996.

In California, private insurers now provide earthquake insurance coverage to homeowners by ceding their exposure to the CEA. The CEA provides coverage to both residential structures and content. The scheme allocates 14 per cent of premium revenue to the participating insurers for distributing and administering the policies and handling claims. Insurance companies that do not participate must offer their own earthquake coverage to their customers. About 30 per cent of the collected premium goes toward purchasing reinsurance and other financial risk transfer products. The rest is pooled in a CEA Fund as reserves. The CEA's overall claim-payment capacity is approximately $US 12.1 billion. The components of this capacity include accumulated capital ($US5.1 billion), reinsurance ($US4.37 billion), bond revenues and insurer assessments ($US2.6 billion) (CEA, 2016b).

The CEA premium rates are calculated based on the property's construction type, the year it was built, and the earthquake risk for its location (19 different rating zones). Its high premium rates and the low collectable claim-payment (deductible excess is 15 per cent of the claimed amount), makes homeowners reluctant to purchase CEA coverage (which is voluntary). Marshall (2017) finds that only 10.23 per cent of California households have seismic coverage.

3. The EQC claim dataset

We use the EQC claim information pertaining to the Canterbury earthquake sequence (CES) for our analysis. The dataset contains information about individual claims for earthquake events in Canterbury region during the CES period.[7] For each claimed event, the EQC data provides the amount paid to claimants or/and spent on repairing damage cost to all three insured exposures (structure, land and content). The EQC claim settlement is capped at $NZ

[7] The CES stated in September 2010. The February 2011 aftershock caused by far the most severe damage, including almost all of the mortality associated with the CES. The last aftershock of the CES was recorded in 2012 (Potter et al., 2015).

100,000 for building structure, and $NZ 20,000 for content. EQC assessment team has apportioned the total repair cost for each exposure and each earthquake event. We use this information as an estimate of the total settlement cost. Given the EQC cap, we can extract the potential amount private insurers would pay for each claim. EQC land cover is the lower value of either the damaged land's value or the repairing cost to its pre-event condition. We set the maximum potential insurance payment at the exposure value. We have data on approximately 230,000 valid CES claims for more than 100,000 properties in Canterbury region. Three fourths of these claims are for building structure. In this paper, we also use the EQC modelled 2010 value of the exposures and 2013 Census household income for our analysis.

Because the EQC caps are applied per dwelling, we adjust the claim payment and exposures' value for the number of dwellings per property. Moreover, to illustrate the data on maps and align with New Zealand Census data, we aggregate and calculate the average values of the claim variables at the area unit level.[8]

4. Hypothetical insurance schemes for the CES

In this paper, we estimate how much the impacted homeowner would have received on average if the JER or CEA scheme had been in place to settle the claim payments post CES. To simulate these insurance settlements, we first need to understand overall damage caused by the CES to each dwelling.

There is a very high penetration rate in New Zealand's residential insurance market; and practically all insurance contracts include earthquake coverage. Consequently, the CES is one of the most insured large disasters in history. Almost all CES damage to residential property was covered by EQC and the private insurers. We aggregate the damage on all three exposures (structure, land and content) to calculate the overall insurance payments.[9] After

[8] Area units are aggregation of meshblocks. They are non–administrative areas that are in between meshblocks and territorial authorities in size.

[9] In the EQC claim data, the excess fee has been already deducted for each claim settlement. For building structure exposure, if the claim value is NZ$20,000 or less, the excess is NZ$200. If the claim value is higher than NZ$20,000, EQC will pay 99 per cent of it. For content exposure, EQC will deduct an excess of NZ$200 for any amount of the claim. For land exposure, if the claim is less than NZ$5,000, EQC will deduct NZ$500 from the claim payment. If the claim value is above NZ$5,000, EQC will deduct an excess of 10per cent up to the

the CES, the New Zealand Government defined specific zones as ‘red’ no-longer-safe zones and bought all residential premises located there. We assume that these properties were thoroughly damaged and owners received payments equal to their value.

4.1. Simulated JER claim payments

We apply the JER claim entitlement, as set in its policy, on the CES residential damage costs to generate what the JER would have paid had New Zealand had a JER-like scheme. Under the Act Concerning Earthquake Insurance, the amount insured is between 30 to 50 per cent. In this case, we assume that all properties that have insurance for structure and content have coverage that is equivalent to 50 per cent of properties’ value. Residential land exposure is not insured by either JER or CEA and is therefore not a JER liability.

The amount insured for the principal contract is capped at ¥JP50 million ($NZ625,000) for building structure with residential use and ¥JP10 million ($NZ125,000) for personal content. According to GIROJ (2014), the amount of JER claim payment is dependent on the earthquake damage to value ratio of the insured properties. On average, impacted residential buildings in Canterbury incurred a loss that is less than 10 per cent of their value. Under the JER settlement method[10], most homeowners would have received only a partial loss payment for building structure (5 per cent of amount insured). Moreover, very few content claims would have been valid because of the restricted policy as set in the JER scheme. The settled amount for claimants would be further lowered when we take into account the JER deductible fee. The excess of a JER claim is the annual premium rate[11] and no more than ¥JP50,000 ($NZ625).

As mentioned, only a thirds of homeowners in Japan have earthquake insurance coverage. In other word, the Japanese insurers could have only covered 30 per cent of CES residential properties in Greater Christchurch under the JER regime. We use this information to generate the average insurance payment virtually for each area unit in the region.

4.2. Simulated CEA claim payment

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maximum excess amount of NZ$5,000. We add this excess fee for each claim when calculating the earthquake damage per dwelling (EQC, 2012).

[10] See the Appendix 1 for the JER claim payment calculation method (MOF, 2016).

[11] Prior the CES, Canterbury region was considered as medium risk zone. Hence, we apply the JER medium risk zone bracket to calculate the JER premium rate for Canterbury region. The required premium is ¥JP9.0 (NZ$0.11) for ¥JP10,000 (NZ$125) of amount insured. The assumed 2013 exchange rate is used.

Similar to the JER simulation, we use the CEA policy information and the actual costs to simulate the claim settlement under CEA regime. California's homeowners have various coverage and deductible options with different premiums fee levels. As we do not have details about the proportional breakdown of these options among those insured by the CEA, we assume all CEA policyholders choose an identical (and generous) policy contract. The insurance payment is capped at $US200,000 ($NZ245,000). The deductible options vary from 5 per cent to 25 per cent of insured amount.[12]

Given the current take-up rate for residential earthquake insurance in California, we assume that 10.23 per cent residential premises in Canterbury region would have had insurance coverage under CEA regime. In other words, nearly 90 per cent of Canterbury households would have been un-insured for earthquake risk.

5. Results

Table 1: Summary Statistics

	(1)	(2)	(3)
VARIABLES (all in $NZ)	Mean	St.d.	Max
Household income in 2013	70,744	24,958	150,000
Dwelling value	430,956	260,471	2.015e+07
Total estimated CES damage per insured dwelling	82,873	153,040	3.355e+06
Total EQC payment per insured dwelling	40,487	58,495	940,947
Hypothetical total JER payment per insured dwelling	9,285	18,530	188,827
Hypothetical total CEA payment per insured dwelling	5,825	9,063	35,661

As described in table 1, a typical residential dwelling that suffered damages in the CES, incurred a loss that was worth 18 per cent of the dwelling value. The EQC payment accounts for only about half the average damage per dwelling. The rest is accounted for by private insurer payments and by the Canterbury Earthquake Recovery Authority (CERA) taking over

[12] The standard deductible was 15% when the program was established, in the past few years, several additional deductible options where added ranging from 5% to 25%. We assume a 15% deductible (CEA, 2016a).

the damaged properties in the residential red zone.[13] In general, the potential settlement for earthquake damage incurred in the CES with JER and CEA insurance coverage are $NZ 9,285 and $NZ 5,825 per dwelling respectively; an amount greatly reduced from the $NZ 40,487 that were actually paid by EQC alone. In other word, the payments under these alternative schemes would have been at most about 18% of the amount that was paid, and 11% of the total CES damages (estimated at $NZ 82,873 average per damaged dwelling).

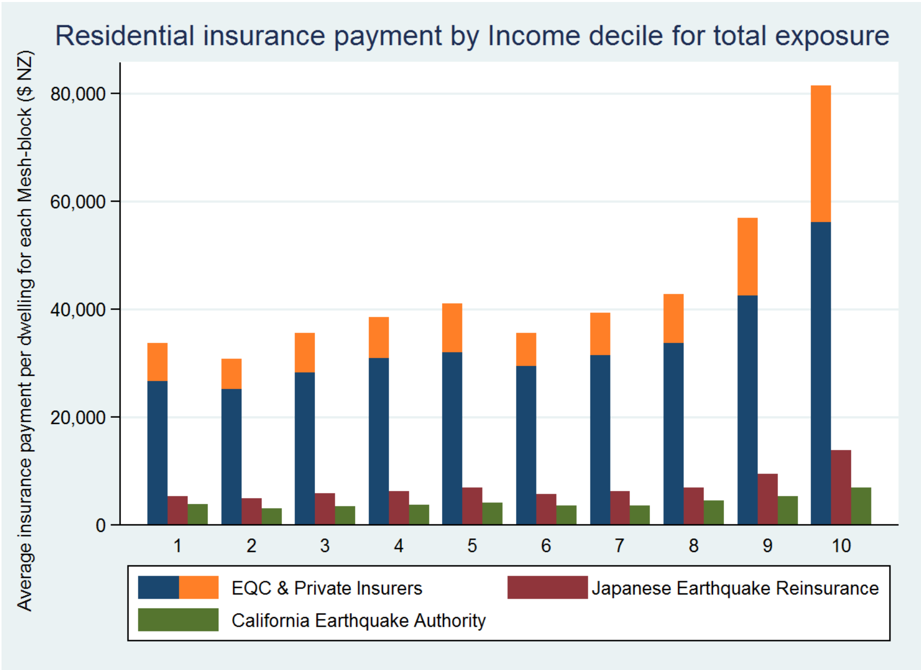


Figure 1: Total CES insurance payouts per dwelling by income decile

As we have detailed data on the claims and their location, we can also match these with socio-economic indicators. In figure 1, we graph the actual EQC payments, and the hypothetical JER and CEA payments, for each income decile.

For most deciles (except the top two deciles), the actual insurance claim payment from the EQC and private insurers sum up to NZ$ 30,000 to NZ$ 40,000 per damaged dwelling. The highest income homeowners received payments averaged more than $NZ 80,000 for their

[13] Following the High Court directive in 2015, the Canterbury Earthquake Recovery Authority (CERA) had fully compensated owners of all properties in the residential red zone. We assume that all red zone properties were damaged at their full rateable value. All owners (including uninsured ones) received a payment offer of 100 percent of the 2007/08 rateable value of their land and building structure. The Crown's compensation payment was assumed to represent the private insurer's payment and was taken into account when calculating the total CES residential cost. As a result, this estimated total cost may be higher than the actual claim settlement by EQC and its private insurers.

combined public and private claim payment. Unsuprisingly, the richest decile also, on average, settle a much larger share of their claim with their private insurers, compared to other income deciles. It is important to note that income deciles are identified at the mesh-block level (roughly about 100 people), rather than at the individual level; the insurance claim data, not surprisingly, does not include the insured party's income information.

Most homeowners that live in high-income mesh-blocks (the top decile) are located in the Port Hills and Fendalton ward. These areas have many expensive residential premises and suffered large loss from the CES. Owen and Noy (2017) also document this finding and provide further information about the ways in which the EQC insurance cover is redistributing money to wealthy (or high-income) owners.

From the simulation, the JER regime would have provided a higher insurance payment than the CEA regime in every income decile. Similar to EQC scheme, the very top decile of highest income earners would have received the highest payout per dwelling under either of the two alternative insurance systems. This picture is not any better at the lower income deciles, so it is not the case that either of these alternative schemes would have provided better treatment of more dis-advantaged groups.

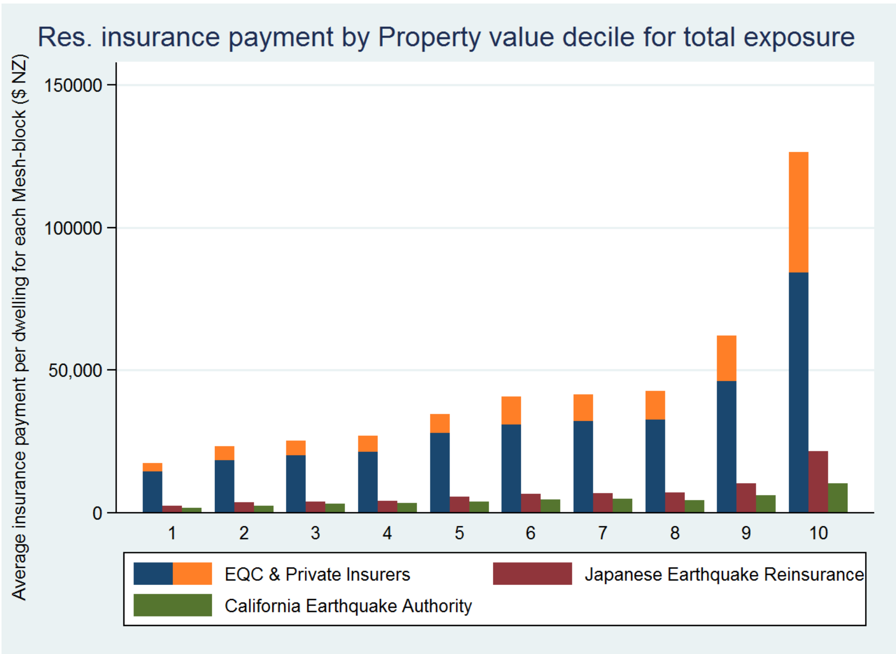


Figure 2: Total CES insurance payouts per dwelling by property value decile

In figure 2, we sort the claims by the insured property assessed value (as provided in the claim dataset for each insured property) rather than by the average income of the insured at the mesh-block level. Since in this case a one-to-one matching of the property information is possible, rather than at the average mesh-block level, and consequently the data is smoother. We observe that the claim payment with regard the property value decile has an increase trend for the actual insurance in NZ (both the public EQC scheme and the top up by the private insurers). Similar to figure 1, the claim payouts' distribution peaks at the the tenth decile for both EQC and the simulated JER and CEA schemes. In fact, the average insurance payment is more than double relative to the nineth decile. In this case, we still observe that the JER scheme would have provided more coverage than the CEA. This difference is more pronounced for the extreme upper value properties.

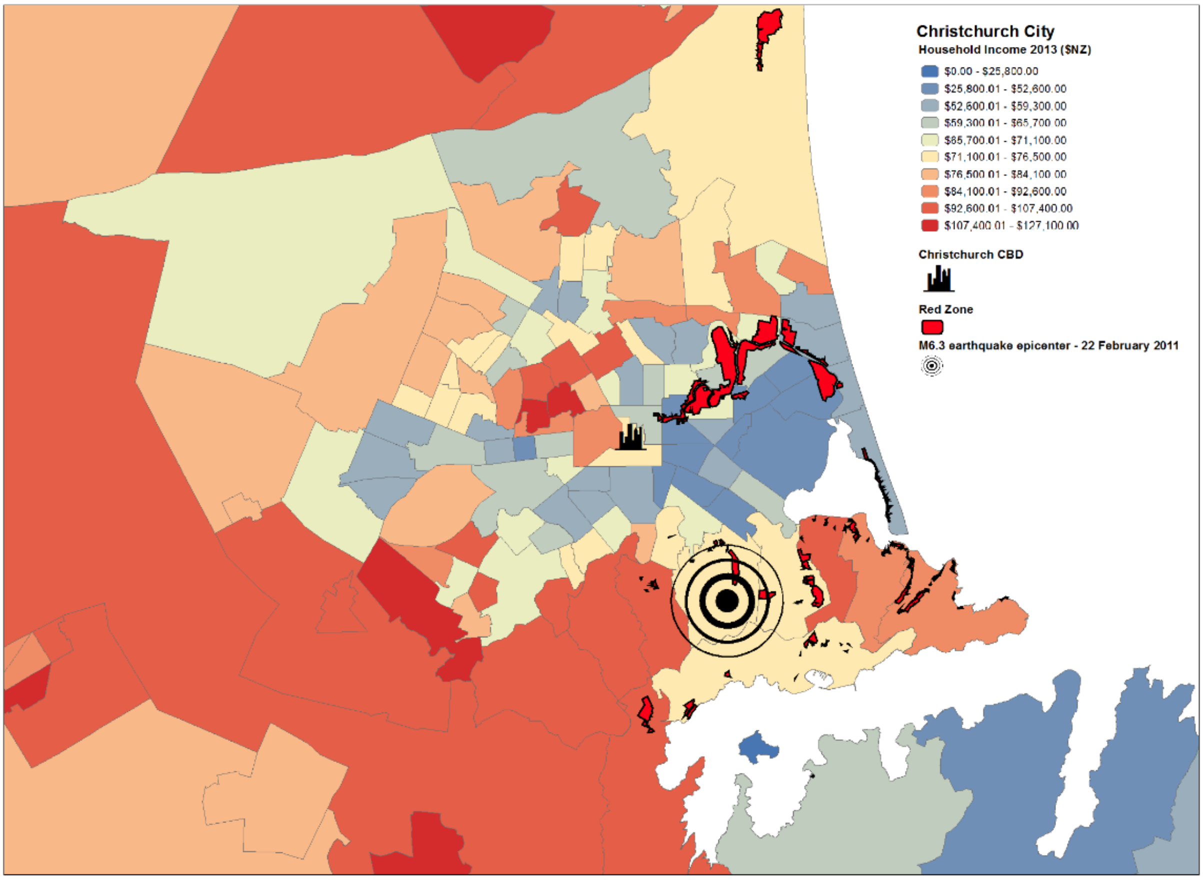


Figure 3: Household income ($NZ) – 2013 Census

As is true in any city, property price vary significantly across suburbs. Households who live in the southwestern and northern outskirts of the city have higher annual income. The South and Northwest of the central city contain high income suburbs such as Port Hills and Fendalton (figure 1). The East and Northeast of the city are generally the lower average income areas. Not surprisingly, average household income and residential property values have a positive relationship (correlation coefficient is 0.56). A map of average property values in Greater Christchurch, similar to figure 3, has a similar pattern to the household income data (see appendix figure 1).

The ruptures of the 2011 earthquake went across the Southeast and the South of the city. The damage caused by shakings and liquefaction to these residential premises was considerable. The damaged dwellings in the wealthy areas (the Port Hills and Fendalton) received much higher insurance claim payment than less wealthy household. However, the earthquake damage cost to Fendalton's residential premises is, on average, 10-15 per cent of the property values. The residential premises that received the highest payout-to-value ratio (20-28 per cent), were mainly locate in the Port Hills. Their land claim payment is higher relative to other impacted areas (appendix figure 2).

As we previously concluded, if JER were the residential earthquake insurance scheme in New Zealand, only 10 per cent of the damage cost to residential property would be insured (appendix figure 3). Unlike EQC scheme, JER claim settlement is based on the damage-to-value ratio. The payment is also dependent on the sum-insured amount agreed in the policy contract. Moreover, JER policy would not cover the damage the earthquake caused to the land (through, for example, liquefaction). The simulated JER content claim payment is also much lower than the actual EQC payment. The damage-to-value ratio of insured personal movables are usually very low and the deductible per claim is high. As a result, few content claims would be valid for insurance payment.

In our simulation, the CEA scheme would only cover 8 per cent of the destruction costs covered by the NZ insurance system for residential property. Although CEA insurance settlement per area unit map have similar pattern to the EQC map, the uninsured residential damage cost under CEA would be much higher. Because CEA does not offer land cover policy, suburbs whose land was highly affected by the 2011 earthquake such as Port Hills, Lyttelton, New Brighton and areas along Avon River would not have land damage compensation. In these areas, the scheme would cover less than NZ$20,000 damage cost per household on average so these areas would be very adversely affected (appendix figure 4). In fact, homeowners in California are clearly under-insured while having a similar earthquake risk to New Zealand. If the same-sized disaster were to happen in an urban agglomeration in California, a typical household would incur an uninsured loss of over $NZ 50,000 ($US 40,000).

We calculate the difference, in each area unit, in claim payment between the EQC and the an insurance scheme (*J*= JER or CEA), using the following:

$$diff_{J,AU}^{EQC} = \sum_{i=1}^{N_{AU}} (EQC_i - J_i) \Big/ N_i \qquad (1)$$

where N_{AU} is number of dwellings (i) in each area unit (AU). Alternatively, we calculate the same difference indicator as a ratio of the dwelling value using equation (2):

$$diffratio_{J,AU}^{EQC} = \sum_{i=1}^{N_{AU}} \left(\frac{EQC_i - J_i}{DwellingValue_i}\right) \Big/ N_i \qquad (2)$$

We then map the area units on a map of the Christchurch area. We present the results of these calculation for equation (2) for the Japanese insurance (figure 4) and for California (figure 5). The maps for equation (1) area units is available in the appendix figures (5 & 6).

The spatial distribution of the 'under-payment' in the case of both the JER and CEA insurance schemes are not that different. Most of the underpayment occurred in the South of the city, and in the East-North-East suburbs. It is surprisingly that the gap between what the EQC paid and what the CEA and JER would have paid is larger for areas that have higher property values and that had a lot of damage because of its proximity to the epicentre (the South). Maybe more worrying is that a large gap is also evident in the North-East, where average incomes are much lower (see figure 3).

In these areas of the South and East-North-East, the average gap. for all the properties in the area units. amounts to about 15% of the value of the property. Since standard home loans (mortgages) required only a 10% deposit (as they do in other jurisdictions), that gap would have meant that the many households—especially newer ones— would have lost all of their previously accumulated household wealth had the insurance regime in New Zealand been more similar to the one in California or Japan.

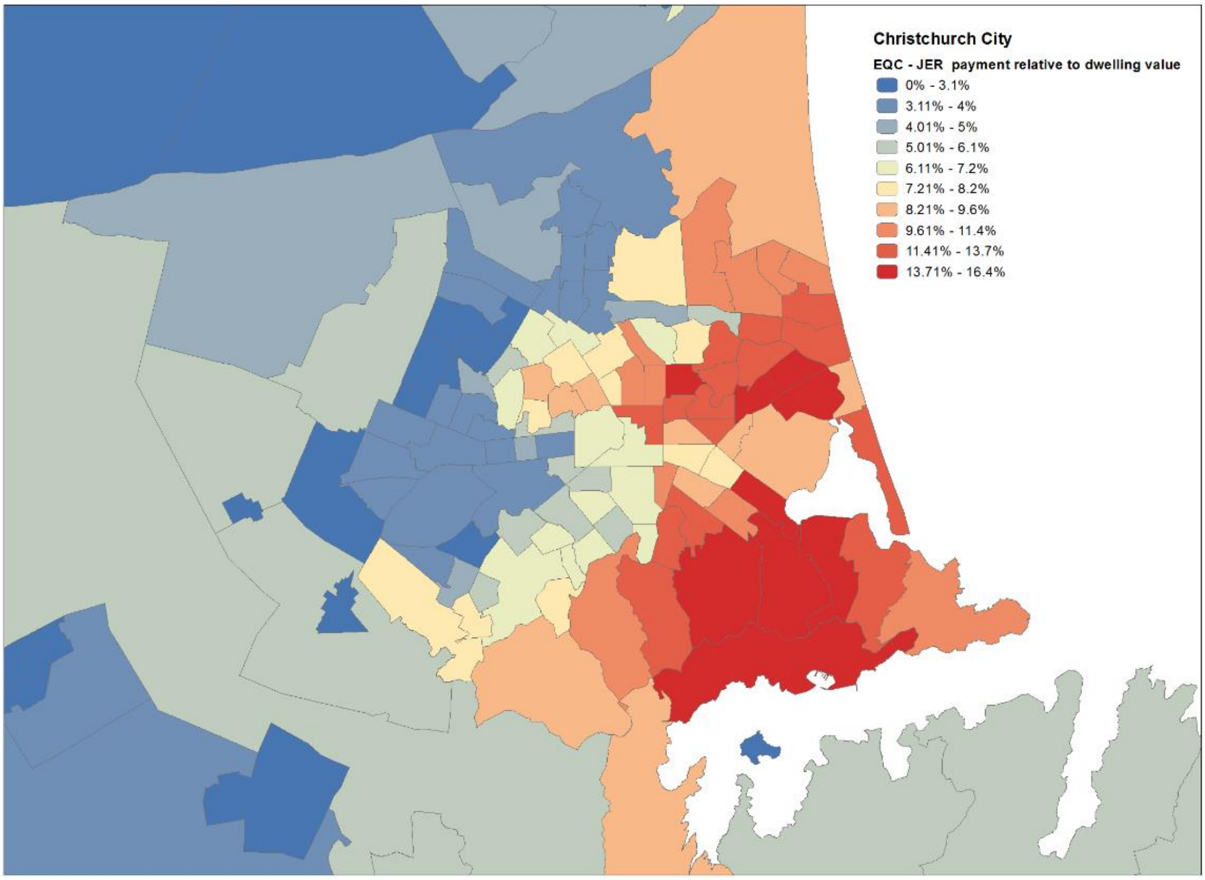


Figure 4: JER simulation – Difference in claim payment be relative to dwelling value

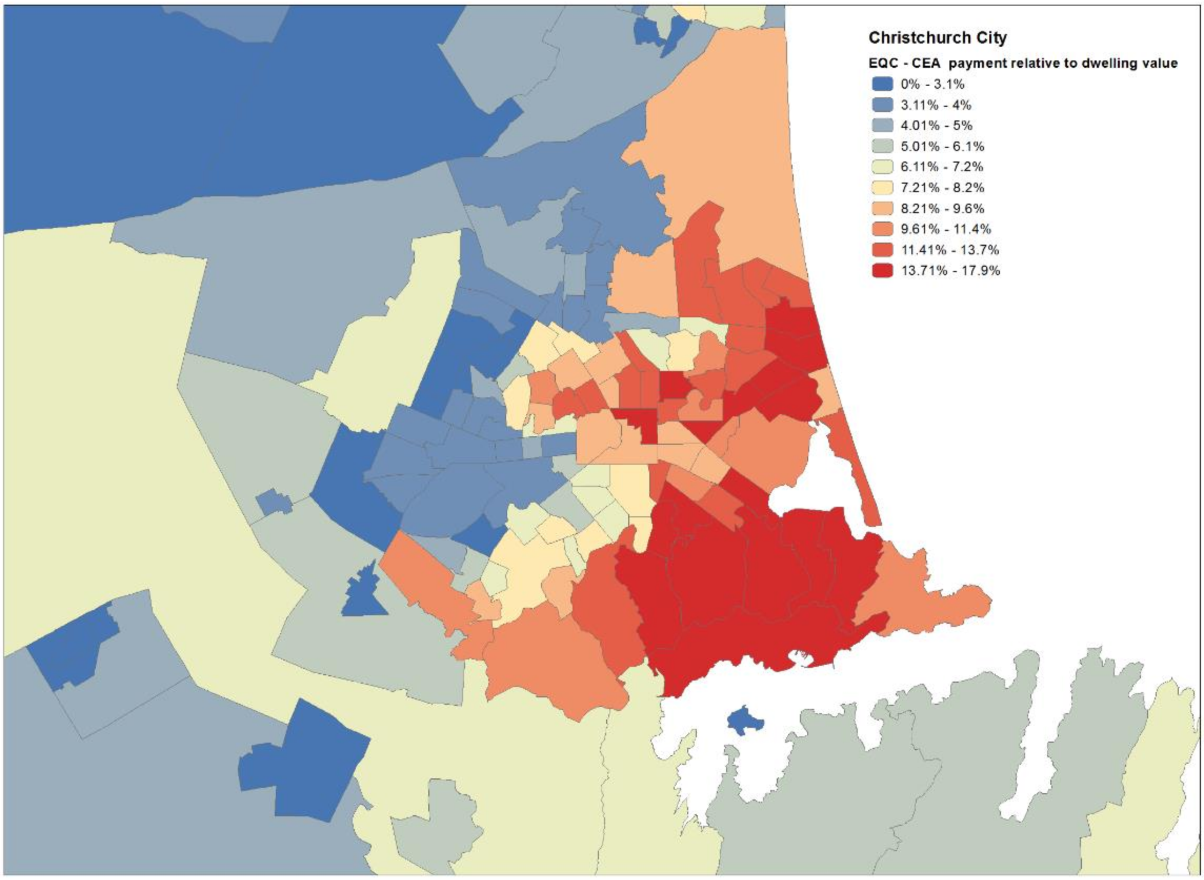


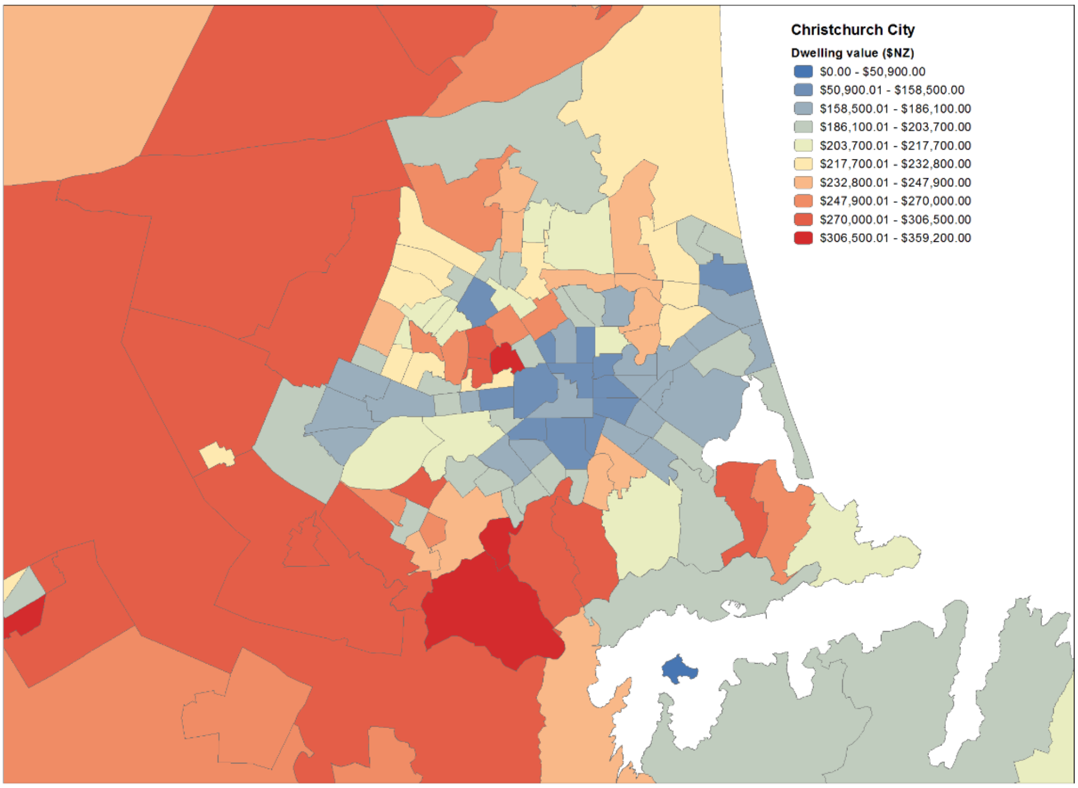
Figure 5: CEA simulation – Difference in claim payment be relative to dwelling value

6. Conclusion

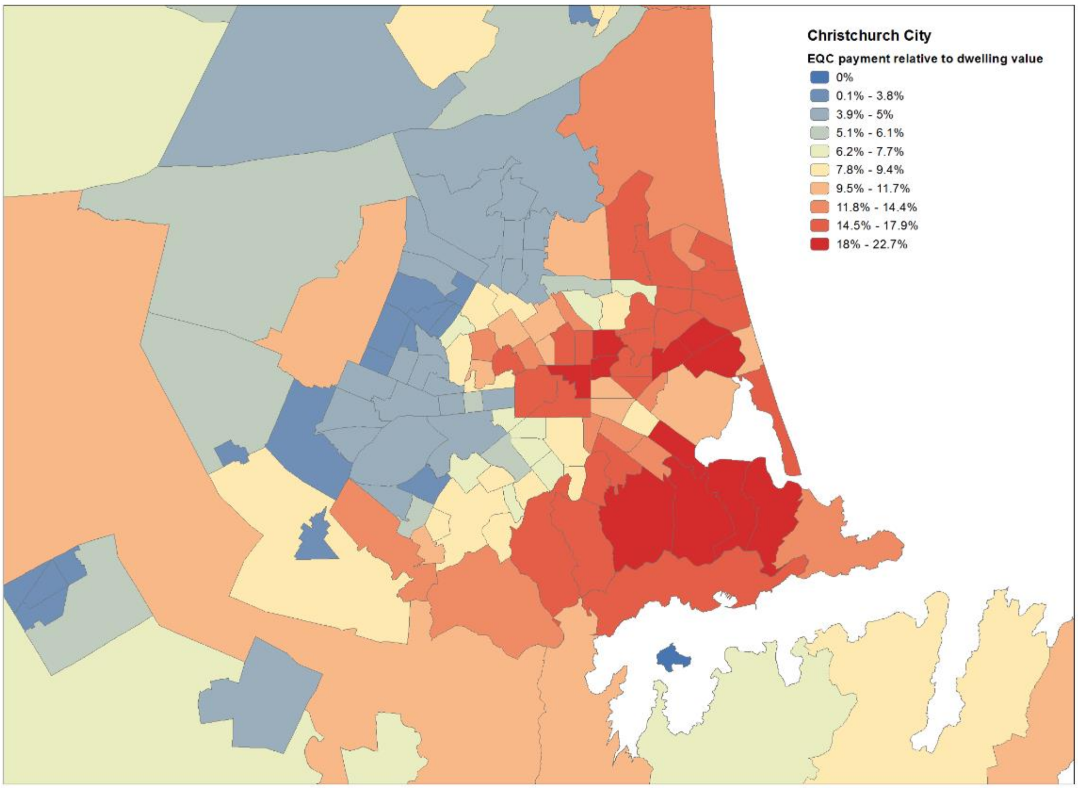
The aggregate EQC spending we record from the data obtained from the New Zealand Earthquake Commission on residential insurance amounted to $NZ11.1 billion in its response to the 2010-2011 earthquake sequence (as of 2016). This figure matches closely with the EQC's 2015-2016 annual report[14]. We estimate that the private insurers have paid an additional $NZ4.3 billion in term of claim settlement for Canterbury homeowners (as of 2016). According to our modelling, if a similar-sized disaster event had occurred in Japan and California, homeowners would have received much less in the form of insurance payment. In the aggregate, JER and CEA would have spent $NZ 2.5 billion and $NZ 1.4 billion for the disaster coverage on residential properties respectively. Payments from private sector insurance that would have been forthcoming are not known, but would also have been much smaller than in the NZ case. So, our estimates of the degree of inadequacy of the California and Japanese systems is an understatement of the gap between these different programs.

[14] According to the annual report, as of 30 June 2016, EQC had paid out an aggregate of $10.8 billion (GST included) for damaged residential properties in the CES.

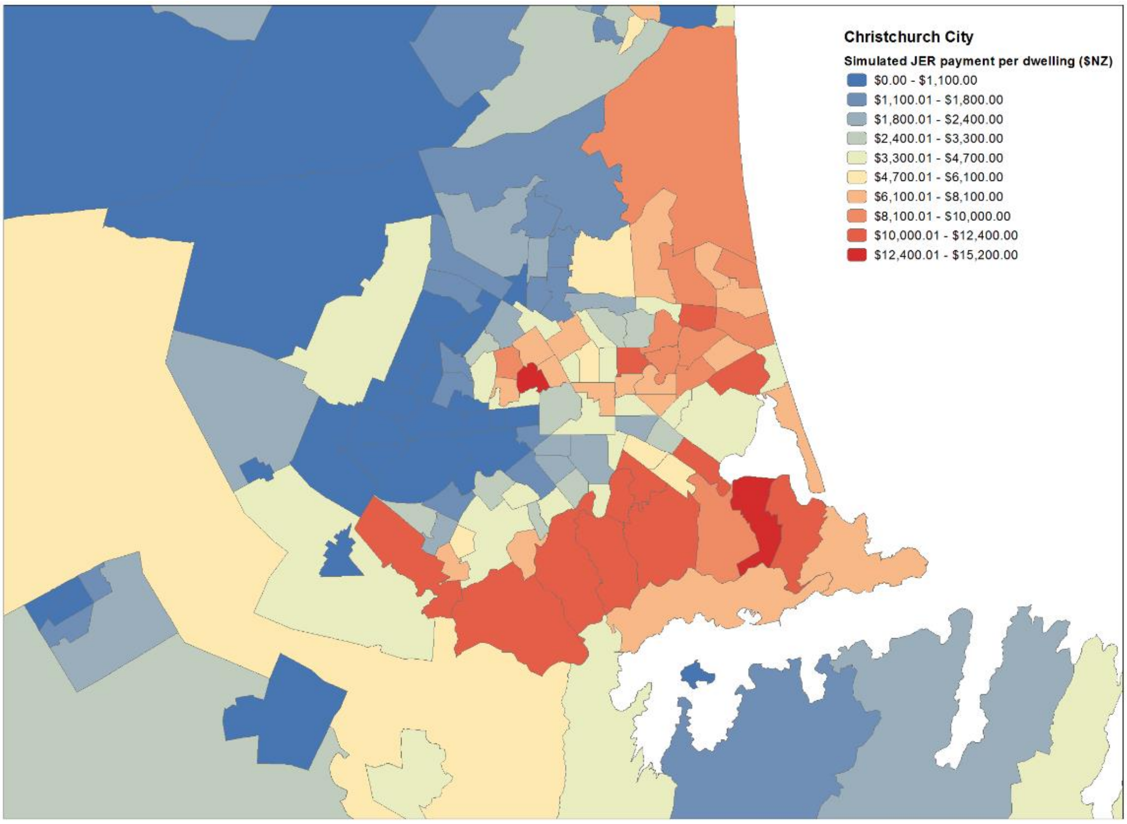
APPENDIX FIGURES



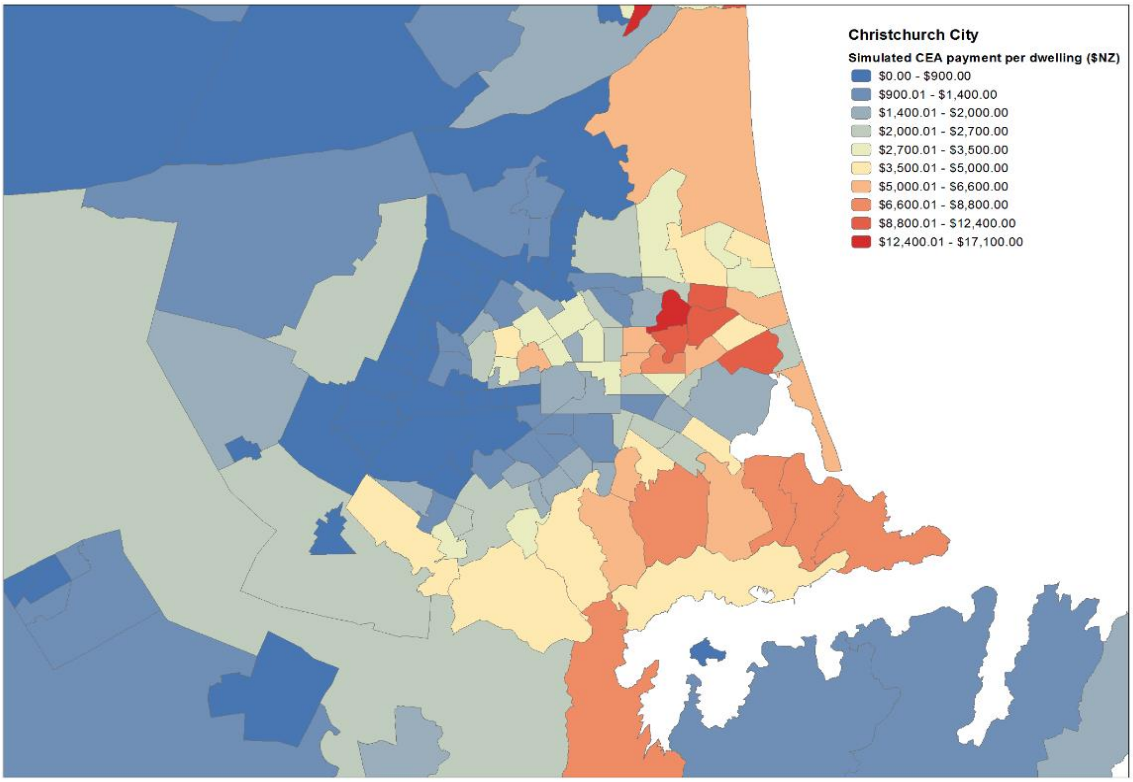
Appendix Figure 1: Average dwelling value



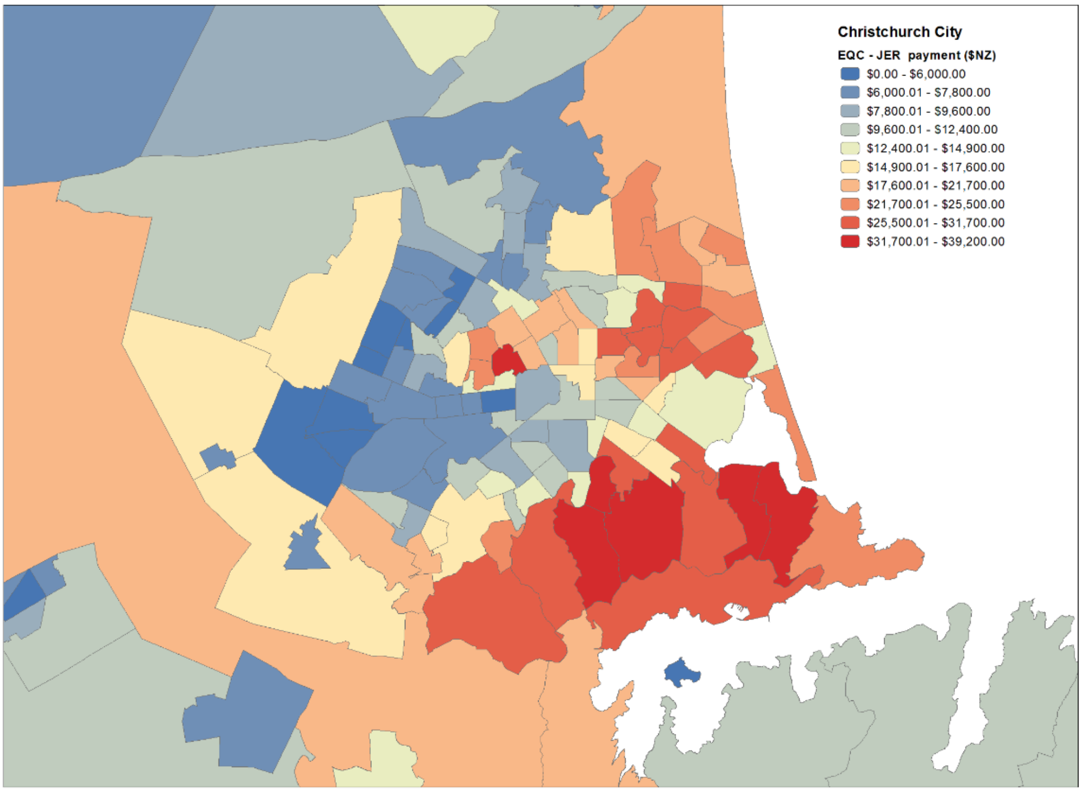
Appendix Figure 2: EQC claim payment to dwelling value ratio



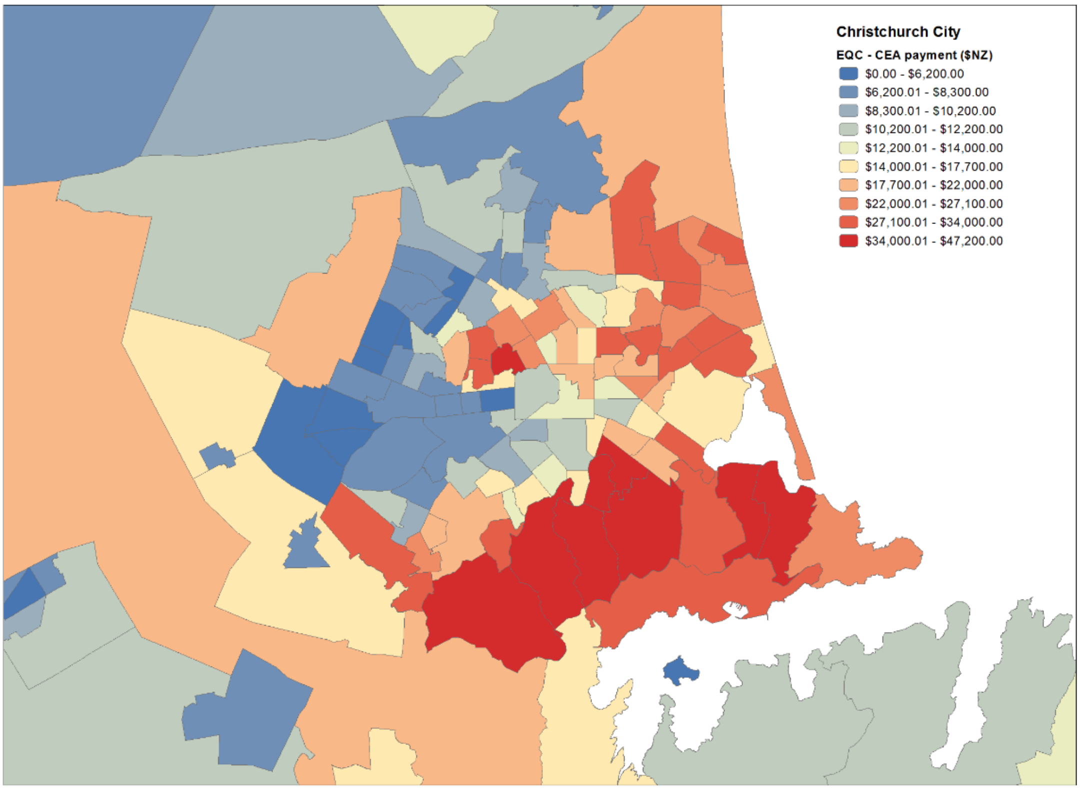
Appendix Figure 3: JER simulation – Average claim payment per dwelling



Appendix Figure 4: CEA simulation – Average claim payment per dwelling



Appendix Figure 5: JER simulation – Difference in claim payment per dwelling



Appendix Figure 6: CEA simulation – Difference in claim payment per dwelling

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