Public insurance and climate change (part one): Past trends in weather-related insurance in New Zealand

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Disclaimer

All opinions are those of the authors. We are also responsible for all errors and omissions.

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Abstract

Climate change appears to be increasing the frequency and magnitude of extreme weather events, negatively affecting communities as well as posing long-term sustainability challenges to insurance (risk transfer) mechanisms. New Zealand's public natural hazard insurer, the Earthquake Commission (EQC), covers homeowners for damage to land (and in some cases to dwellings and contents) caused by landslip, storm or flood. We comprehensively explore the EQC claims data to investigate these weather-related claims from 2000-2017. We find no clear upward trend yet emerging in the number of claims or their value. We find that the northern regions of both islands are the source of most claims, that only a handful of weather events caused a large proportion of EQC's weather-related pay-outs, that the average property lodging a weather-related claim is located twice as close to the coast as the national average, and that properties with claims usually are cited on much steeper land than the typical property in New Zealand. We also explore the relationship between claims and socio-economic characteristics, finding that higher income neighbourhoods appear to be those most benefiting from the EQC coverage for weather events.

JEL codes

G22, G28, Q51, Q54, Q58, R28

Keywords

climate change, extreme weather, natural hazards, public insurance, New Zealand

Summary haiku

Climate change concern:
many insurance costs from
weather already

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1 Introduction and Overview

The world appears to already be facing higher frequency and intensity of natural hazards and disasters associated with extreme precipitation (landslips, floods and storms), compounded by sea level rise. All as a consequence of climate change (IPCC, 2012; IPCC 2014; UNISDR, 2015). Compounding this, the exposure of communities to hazard events is likely to rise further, due to people continuing to move to areas that are more weather-risk-prone such as coasts and river deltas (Noy, 2016).

In this paper, we study New Zealand (NZ), an island nation exposed to oceanic storms. NZ has seen many weather events affecting communities across the country in the last 20 years (ICNZ, 2018). Using insurance data, we investigate this risk in NZ and analyse the data from insurance claims received by the NZ public natural hazard insurer, the Earthquake Commission (EQC).

Insurance systems are a key financial risk transfer tool used by millions of households across the world to ameliorate adverse financial consequences from unlikely (small probability) disasters. As such, insurance systems have proven both popular and useful for the economic recovery and prosperity of entire regions, communities and households (Mills, 2005). In NZ, more than 90% of households purchase private residential property insurance. Since 2000, NZ households have received more than $1.4 billion in insurance compensation related to extreme weather events (ICNZ 2018). The focus of this paper is the coverage for weather-related events—landslips, storms, and floods.[1] The data we use includes more than 26,000 weather-related claims lodged between 2000 and 2017 to the EQC. It allows us to identify households affected by extreme weather events, geographically and over time.

We use these EQC claims to observe how weather-related events have translated into financial liabilities for the Crown, through EQC claim pay-outs after weather events. We analyse how these claims are distributed across the country given their geophysical characteristics and the socio-economic characteristics of the affected neighbourhoods.

1 Note that we are only interested in landslips caused by weather events (usually excessive rain), and not landslips triggered by earthquakes.

Further to the public insurance data, we utilise:

- extreme weather events across the country from the Historic Weather Events Catalog (NIWA, 2018a),
- neighbourhood demographic and socio-economic information from the NZ Census (StatsNZ, 2018),
- Topographic and land cover features (LINZ, 2018), and
- aggregated private insurance payments for each weather event (ICNZ, 2018).

We used open-source QGIS software to map the main features of these datasets and associated them with the geo-referenced EQC claim information.

Our work shows that Northland and the Bay of Plenty are the regions with the highest proportions of people and properties affected by weather events in the North Island of New Zealand. In the South Island, the Nelson and Tasman regions are the most affected. Since 2000, there have been five significant weather events (four of which happened in these regions), which account for around a third of the total weather-related pay-outs made by EQC. We find that, even though most properties in New Zealand are located close to the coast, properties reporting claims to EQC are located even closer. While the average property in NZ is approximately 11km away from the coast, the average property lodging a claim to EQC after a weather event is located only 6km away. Though the quantity of claims is highly correlated with population, there is no clear correlation between claim frequency (or pay-outs) and population growth. The topography (slope) does, however, appear to be a determining factor.

Finally, we show that weather-related EQC claims tend to come from areas with higher median incomes. We found that areas in the top two income quintiles tend to report more than half of the total claims and pay-outs made. This finding suggests that after extreme weather events, higher income families may make more use of EQC insurance coverage than the average New Zealand family. The reasons for this increase in EQC pay-outs associated with higher income households are not entirely clear. They could be associated with better access to the system, higher exposure due to location choice, higher damages caused by higher asset values, or having more land exposed.

Generally, household-level private insurance information on claims is unavailable for research purposes. NZ's publicly funded insurance system therefore provides a novel and enlightening source of insurance data. For NZ, this study is the first in-depth analysis of EQC claims data for weather-related events. Worldwide it is one of very few studies that uses property level insurance claims data to analyse the impacts generated by weather events.[2]

This paper is the first in a series which ultimately aims to project the financial liability from climate change for the EQC. Here, we have only begun to provide insights about the

2 See Kusuma et al. (2017) and Savitt (2017) for recent surveys of this literature, and Surminski (2014) for specific discussion of flood insurance.

increasing risk that current and future residential areas might face, given the possibility of increasing frequency of extreme weather events.

2 NZ public natural hazard insurance and climate change

In this section we briefly describe other public natural hazard systems globally, give more detailed background on the New Zealand system, and how weather-related coverage works in NZ.

2.1 Placing the NZ system in a global context

There are at least fifteen public or public-private established natural hazard insurance systems worldwide for personal property. Of these:

- some cover homeowners for a range of natural hazards (Austria, Belgium, France, Iceland, Norway, NZ, Romania, Spain, Switzerland),
- a handful relate only to flood insurance (USA, UK, Denmark) and
- two state-level programs cover windstorm damage (Florida and Texas in the USA)[3].

All these insurance systems cover hazards for which frequency and intensity will likely be affected by climate change. The EQC scheme belongs to the group of schemes covering homeowners for a range of different types of natural hazards.

2.2 The NZ Earthquake Commission (EQC)

Government-provided earthquake insurance started in NZ in 1944, after several devastating earthquakes. The Earthquake Commission Act (1993) specifies that, in addition to covering damages from seismological hazards, EQC will also provide insurance cover for residential properties affected by landslips, and for damages to land on which houses are located as a consequence of storms and floods.

2.3 Coverage of weather-related events by EQC

EQC's main function is to insure homes, their contents and the land below and around them against damages by *earthquakes*, *volcanic eruptions*, *natural landslips*, *hydrothermal activities*, and *tsunamis*. Cover also includes *fire* following any of these disasters. This cover includes buildings, contents, and the land on which the insured residential property is located.

Additional cover is also provided for residential land damaged by *storm* or *flood*; this cover is available for land only (EQC, 2011). It is precisely these last types of cover (land for

3 Owen and Noy (2017).

storms and *floods*), and *landslips* (following weather events), that we focus, as they directly relate to weather events. This coverage is classified in EQC's database as a single category called "landslips/storms/flood".

In contrast with earthquakes and geothermal hazards, EQC does not cover all types of damages that may result from floods and storms. The cover mostly focuses on the land underneath and surrounding residential properties. This is unusual as, in most countries, land is not an independently insurable asset.

The unusual aspect of this coverage is exemplified by EQC's statement that:

> *"The market failure arguments for EQC's cover of landslips, and land cover for storm and flood, are arguably not as strong as for events such as earthquakes and volcanoes. Nonetheless, any changes in cover would need to be carefully considered to identify the likely functioning of private markets in that area, and ensure that the transfer of risks and benefits was appropriate, particularly given historic land use decisions." (EQC, 2011).*

3 EQC weather-related claim information

In this section we describe our primary data; claims and property information from the Earthquake Commission (EQC).

We were fortunate to have access to all the EQC insurance records. Since 1980, EQC has received over half a million claims. Four percent of all claims have been classified under the "landslip/storm/flood" category, i.e. relate to weather events. This represents more than 25,000 claims paid by EQC as a consequence of weather shocks in the last 18 years. These have a total value close to NZ$ 300 million.[4]

The claim dataset includes information about the date of the event, the claim itself (e.g. its status), and the amount paid by the EQC. The dataset can be linked by a unique property identifier to another dataset that contains location information (longitude latitude pairs with a 70m anonymization offset) and property characteristics (e.g. construction type, wall materials). These records are unreliable for the period before the late nineties, and therefore we restrict our sample to post-millennium events, which make up 26,180 claims. Table 1 contains summary statistics for this sample.

4 $1 NZD ~ $0.75 USD (as of February 2018)

Table 1 - Descriptive statistics: NZ Landslip/Storm/Flood claims (2000 - 2017)

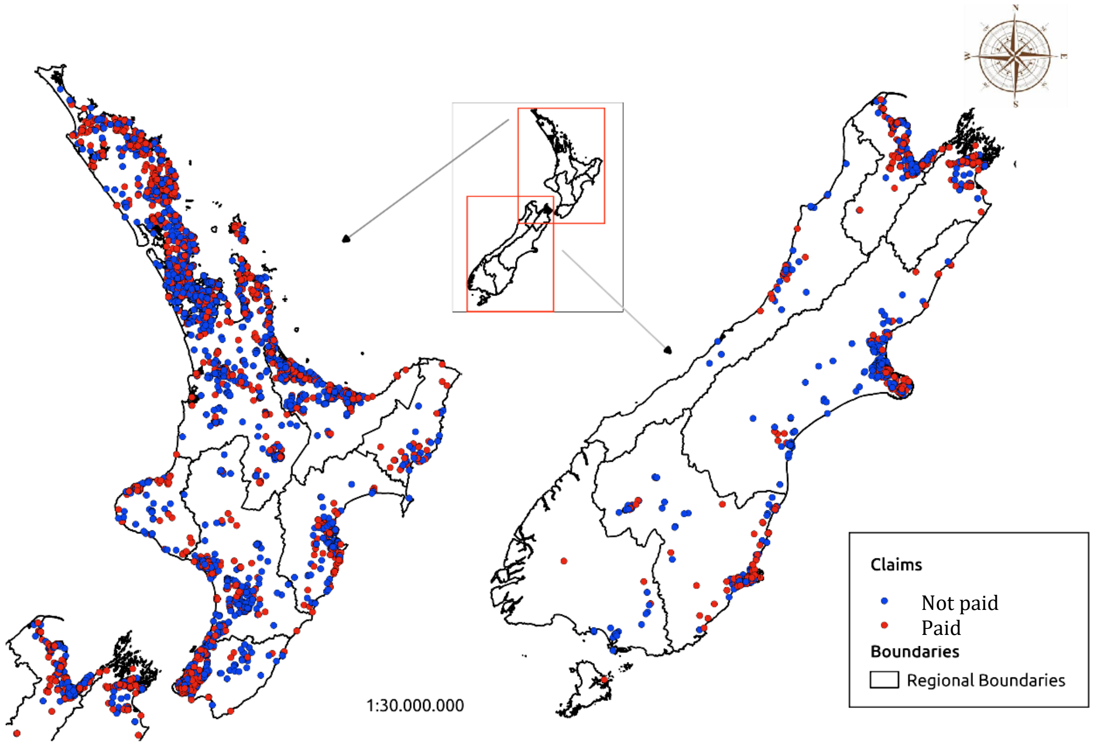
Total number of claims received	26,180
Claims with property location data	18,930
Unresolved claims	803
Claims from properties that had lodged a prior claim	2,194
Total amount paid for land damages (millions)	$ 198.89
Total amount paid for building damages (millions)	$ 92.99
Total amount paid for contents damages (millions)	$ 2.62
Number of resolved claims - including zeroes	25,377
Mean amount paid - all resolved claims including zeroes	$ 11,420
Standard deviation of amount paid - all resolved claims including zeroes	$ 40,340
Number of resolved claims - excluding zeroes	14,546
Mean amount paid - all resolved claims excluding zeroes	$ 19,930
Standard deviation of amount paid - all resolved claims excluding zeroes	$ 51,670

Notes: This table contains descriptive statistics, for claims classified as 'Landslip/Storm/Flood', which were lodged with New Zealand's public natural hazard insurer (the NZ Earthquake Commission "EQC") between Jan 2000 and Oct 2017. "Claims with property location data" refer to those for which EQC hold the data to link the claim's unique property identifier to longitude-latitude coordinates. Unresolved claims are those which EQC classify as 'Open' – where the claim has not yet been settled. A prior claim refers to claim lodged relating to a different weather event. 'Zeroes' refer to claims which were lodged but for which the records indicate that the EQC did not pay out. All monetary values are expressed in 2017 NZ dollar values (specifically, by inflation using the NZ CPI to the second quarter of 2017). All claims exclude GST.

As seen in Table 1, there are 18,930 geo-referenced claims (see Figure 1 for a map of these). There are 803 claims that have an 'open' status as of dataset retrieval (October 2017), meaning they have not been officially resolved. However, as some of these claims do report pay-outs made by October 2017, we include their values in aggregated analyses. By restricting our sample to resolved claims that receive a non-zero pay-out, the average weather-related claim payment reached NZ $19,930.

For households to be covered by EQC the property is required to be covered for fire damage by a private insurer. EQC claim data shows that there were 3,785 households that did not verify a private insurer to EQC. An additional 54 claims were from properties that had already lodged a claim in the same event, resulting in a zero pay-out as consequence of being a repeated claim (damages, if valid, were covered in the original claim). After removing these claims, we still have 6,992 settled claims where the zero pay-out could be explained by points c) to f) below.[5]

Figure 1: Map of locations of EQC-weather related claims



Notes: This figure shows the location of weather related claims made to New Zealand's public natural hazard insurer (the New Zealand Earthquake Commission [EQC]) from January 2000 to October 2017. Weather related claims are those classified in a single category as "Landslip/Storm/Flood", which exclude earthquake-related landslips. Of the 26,180 weather-related claims lodged in this period, only 18,930 are able to be linked to a geo-referenced property ID and thus mapped. Claims which are "not paid" had not yet been resolved as at time of data retrieval.

Of the total number of claims that were settled, 41% record a pay-out of zero. Reasons that may explain a zero pay-out include:

a) the household did not have private insurance (3,785 households)

b) claims referred to damages already assessed and covered (i.e. the record is a duplicate)

c) the damage was outside scope (EQC's limits covered land damage to 8 meters around the covered buildings, plus the main access way to the property)

d) the cost was under excess ($500 for land damages)

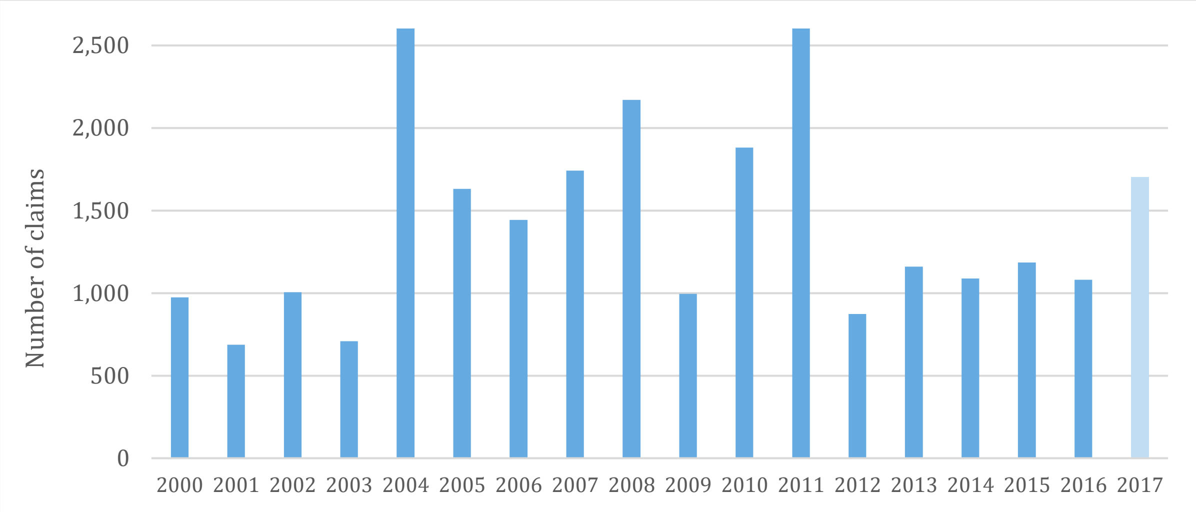
e) the damage was assessed to be caused by something other than landslip/storm/flood (e.g. was pre-existing damage)

f) the claim was made after the deadline for submitting claims had passed (the deadline to submit is 3 months after the event)

5 An extra 424 settled claims have a pay-out of zero after being rejected by EQC for building damages coverage, but the specific reasons are not explained.

Regarding the temporal dimension of the data, the claims range from January 2000 to October 2017. The number of claims received per year are shown in Figure 2. There is no discernible trend in terms of the number of weather related claims made over these years.

Figure 2: Total number of weather-related claims received by EQC per year

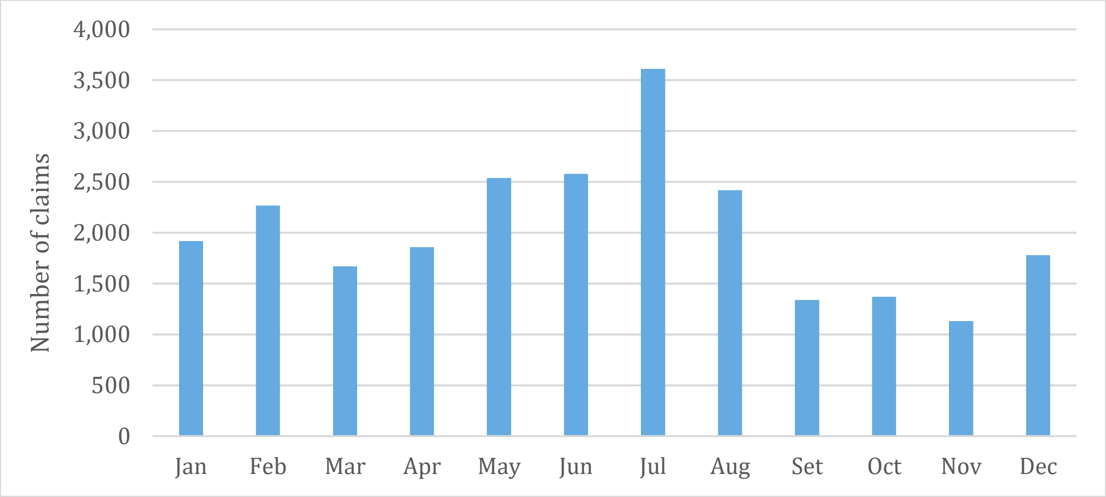


Notes: This figure shows the annual number of weather-related claims (those classified as "Landslip/Storm/Flood") made to New Zealand's public natural hazard insurer (the New Zealand Earthquake Commission [EQC]) between Jan 2000 - Oct 2017. This dataset is made up of 26,180 claims, including those which do not have a geo-reference, are unresolved, or have recorded a zero pay-out claim.

In Figure 3 we show the average number of claims received in each month across years, to better understand the distribution of claims received within a year. There is a clear seasonal pattern, with a concentration of claims in winter months (May-August, with a distinctive peak in July) and in summer months (December-February).[6] This pattern relates to the concentration of storms in winter months, and heavy rainfall events that can occur during summer such as ex-tropical cyclones. Spring and autumn report consistently fewer claims, which reflects the lower average frequency and intensity of damage-causing extreme weather events in these months.

6 Note to the reader: New Zealand is located in the southern hemisphere, so seasons are opposite to the northern hemisphere.

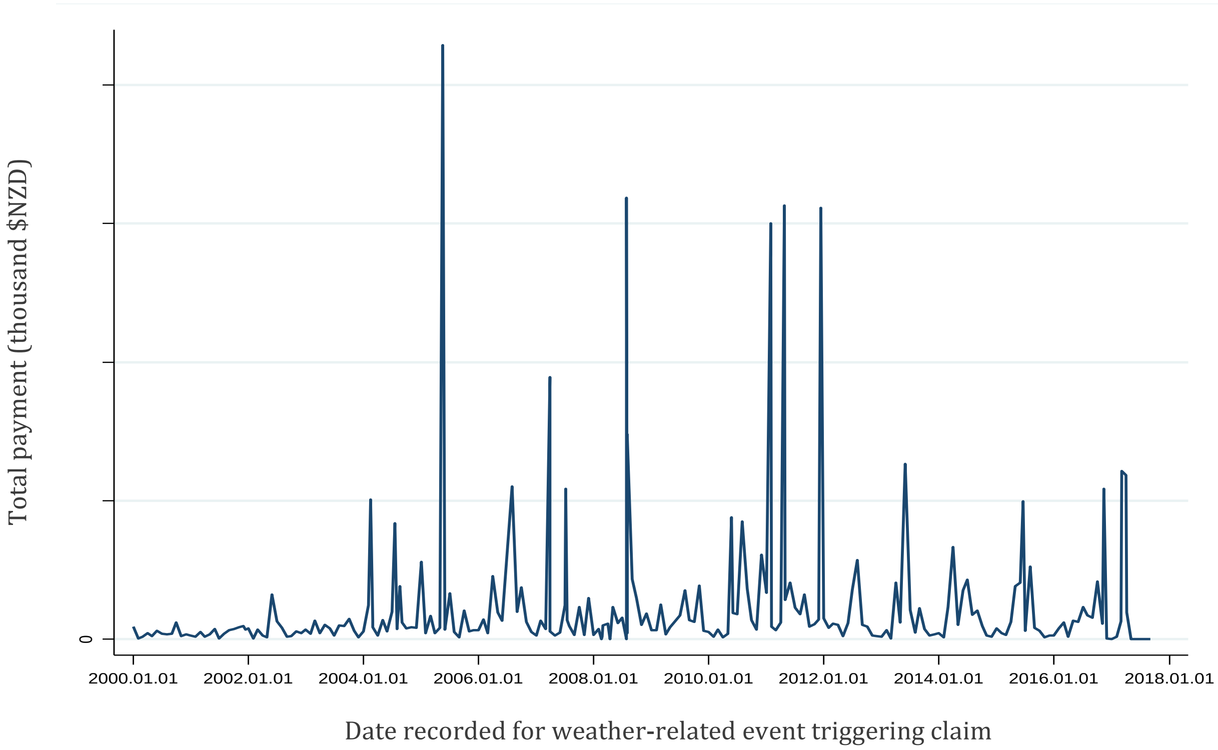
Figure 3: Number of weather-related claims, by month of claim lodging



Note: This figure shows the number of weather related claims lodging (classified as "Landslip/Storm/Flood") by month of claim, made to New Zealand's public natural hazard insurer (the New Zealand Earthquake Commission [EQC]) between January 2000 - December 2016. This figure excludes claims in 2017 as we only have data till October of 2017. This dataset is made up of 24,478 claims, including those which are non-geo-referenced, unresolved or zero pay-out claims.

In Figure 4 we present a series of EQC weather-related claim pay-outs by month, since 2000. There are five clear peaks in 2005, 2008, and on three occasions in 2011. These are discussed in more detail in Section 5, where we introduce detailed historic weather information. Once again, there is no clear upward trend in this series.

Figure 4: EQC weather-related claim pay-outs over time



Notes: This figure shows the total pay-outs for weather-related claims made to New Zealand's public natural hazard insurer (the New Zealand Earthquake Commission [EQC]) from January 2000 to October 2017. Weather-related claims are those classified in the single category of "Landslip/Storm/Flood", which excludes earthquake-related landslips.

In terms of location of the properties making claims, EQC provides the properties' location (latitude and longitude) with a 70-metre rounding. This data was originally supplied to EQC by Corelogic (2018). In the map (figure 1) it is seen that, not surprisingly, most claims are located in the larger population centres of the country. The highest concentration of claims is found in metropolitan Auckland, the largest city in New Zealand. Wellington and Christchurch (the second and third largest cities) also report a high concentration of claims. However, it is worth noting that some less populated areas, such as the Bay of Plenty (on the east coast of the North Island) and the Nelson/Abel Tasman region (at the northern tip of the South Island), also present a significant concentration of claims, suggesting their exposure and vulnerability to extreme weather events.

4 EQC claim pay-outs compared to private insurance data

In this section we introduce a second dataset, of aggregated private insurance payments, and compare this to our EQC dataset.

4.1 Private weather-related insurance payment data

Our second dataset is sourced from the Insurance Council of New Zealand (ICNZ, 2018). These aggregated private insurance figures include data from all insurers who are members of the Insurance Council of New Zealand (ICNZ). As ICNZ members underwrite more than 90% of all policies underwritten in NZ, this captures a very large proportion of the private market. Unfortunately, these data are available by disaster event only, and do not include details on number of claims or location of properties. We create a sample from this dataset containing the total reported dollar values of private insurance payments related to “weather-related natural disasters” in NZ. Droughts are not included. (ICNZ, 2018)

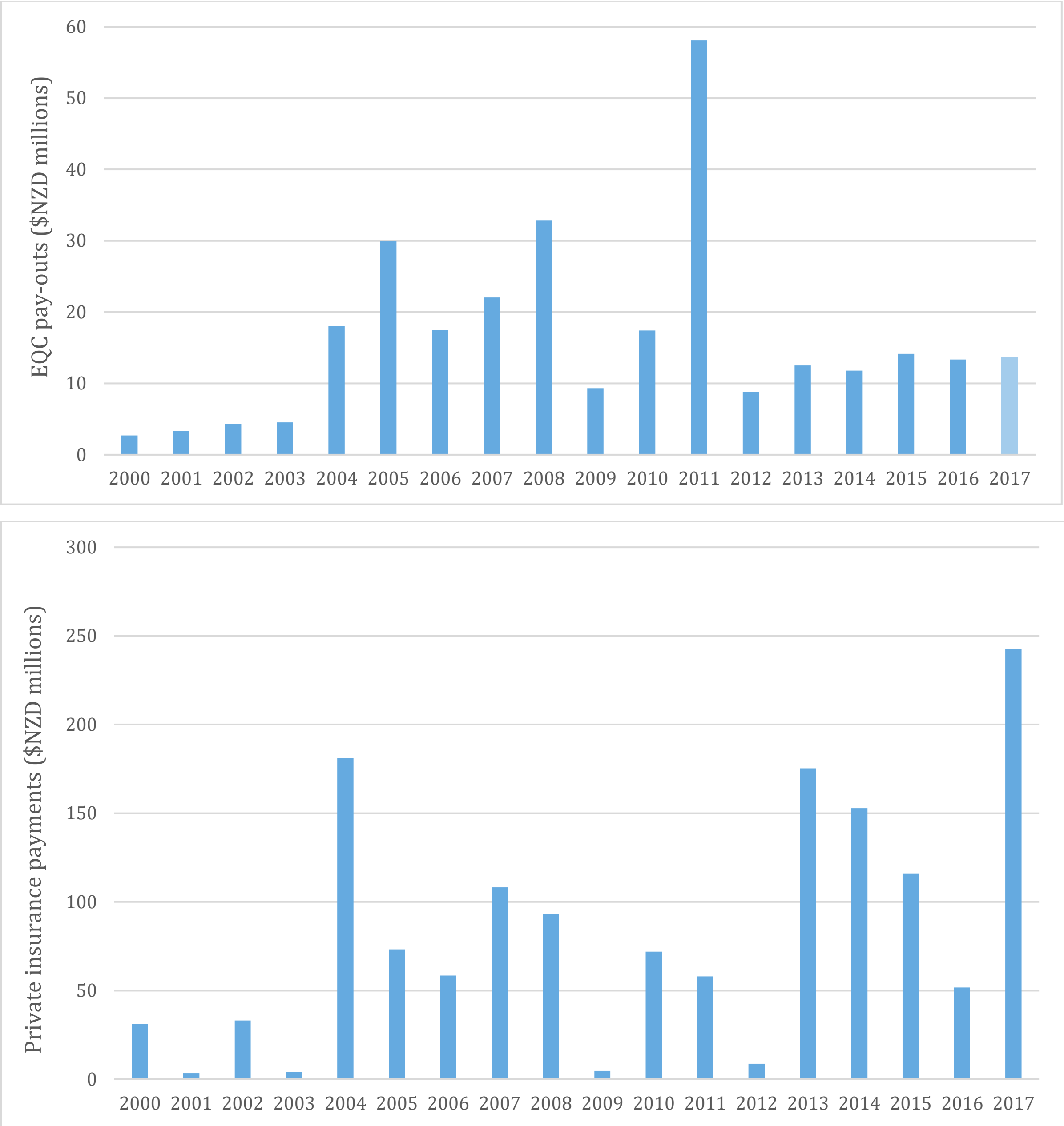
4.2 Comparing the EQC claim pay-outs to this private data

Figure 5 presents the total value paid out by EQC over the years since 2000. The pay-out values follow a similar pattern to that of the number of claims described earlier, and shown in Figure 2. 2011 is highlighted as an expensive year for weather-events for EQC, 2005 reported the 3rd highest pay-out across years, but is only 6th in terms of numbers of claims received. As we detail later, this is likely explained by one particular event that triggered the highest total pay-out made by EQC for a single event since 2000 (see Table 2).

In addition to the sum of property level pay-outs from EQC, in Figure 5 we also present the total annual values paid by NZ private insurers after a weather-related disaster. An important point to emphasise is that the scale of the bottom chart is around five times larger than the upper one: the total amounts paid by private insurance are much higher than those paid by EQC. This is expected, since EQC only covers specific damages, while private insurance is generally liable for a wider range of property damages (including damages to commercial properties and flood-related damage to dwellings).

Figure 5 shows that in the early 2000s, there were fewer costly events affecting properties in NZ, while more damages occurred after 2004. There were low liability years for private insurance in 2009 and 2012. 2011 is remarkable: while for EQC it was the year with the highest relative financial burden, for private insurers it was below the average. These differences suggest that the 2011 events, on average, damaged more land than property structures compared to other years. The last year for which we have data, 2017, also presents an interesting contrast, as it was the costliest year for private insurers, but less exceptional for the public system.

Figure 5: Total value of weather-related: EQC pay-outs (upper) and private insurance payments (lower)



Note: This figure compares public and private weather-related insurance pay-outs per year, between 2000 and 2017. The upper panel shows the annual sum of property-level weather-related pay-outs (classified in a single category as "landslip/storm/flood") by New Zealand's public natural hazard insurer (the New Zealand Earthquake Commission [EQC]) between January 2000 and October 2017. All EQC pay-outs exclude GST, and are expressed in 2017 New Zealand (NZ) dollar values (specifically, these were adjusted using the NZ CPI to the second quarter of 2017). In the lower panel, we present the total reported dollar values of private insurance payments related to "weather-related natural disasters" in NZ. Drought are not included. These aggregated private insurance figures report to include data from all insurers who are members of the Insurance Council of New Zealand (ICNZ). ICNZ members underwrite more than 90% of the policies underwritten in NZ. These data are available by disaster event only, and do not include details on number of claims or their locations. This data is sourced from ICNZ (2018).

5 Weather-related insurance and historic weather data

In this section we introduce weather and geographic data, and compare both the public and private weather-related insurance claims to these.

5.1 Including NZ Historic Weather Events information

The NZ Historic Weather Events data is provided in NIWA's online catalogue. This dataset contains date information, an event name, and extensive characteristics associated with the event such as location of the impacts, description of the effects, and type of hazard (storm, flood, etc.) (NIWA 2018a). This information can be linked to the insurance data by comparing weather date and location to property coordinates and date of claim. The web link for the particular events from this historic weather database, where we obtain the name and characteristics of most of the events used in our analysis, is provided in the Appendix. The only exception was the event 'Lower North Island flooding/wind', which was not recorded by NIWA (2018a), but was included in the ICNZ (2018) dataset.

5.2 Comparing the insurance information to this weather data

In Table 2, we present information on the dates between 2000 and 2017 which led to the highest total public and private insurance pay-outs. In addition to pay-out figures, this table also reports the number of weather-related claims received by EQC for that date, as well as the total amounts paid by private insurance companies for the full events.

This data sheds light on our earlier Figure 4, which had five obvious peaks. Three out of the five events happened in the north of the North Island, while the others occurred in the north of the South Island (Nelson/Abel Tasman region). This spatial identification aligns well with the fact that these are the two regions of NZ most exposed to ex-tropical cyclones and storms from the Pacific Ocean. It was the 2005 flooding event in the Bay of Plenty - Waikato region which generated the highest pay-out for EQC.

Table 2: Eleven recent New Zealand weather events which triggered significant insurance pay-outs

(1)	(2)	(3)	(4)	(5)
Date of beginning of weather event	Weather event *characteristics*	Number of EQC claims for first day of event	Sum of EQC claim pay-outs for first day of event (2017 $NZD)	Paid by NZ private insurance following full event ($NZD)
2005.05.18	Bay of Plenty and Waikato Flooding *heavy rain*	795	$21,400,000	$28,500,000
2008.07.26	North Island Weather Bomb *high winds, seas and rainfall in several regions of the country*	890	$15,900,000	$26,700,000
2011.04.25	Hawke's Bay Flooding *four days of heavy rain*	429	$15,700,000	$6,400,000
2011.12.14	Tasman-Nelson Heavy Rain and Flooding *no description*	964	$15,600,000	$16,800,000
2011.01.29	Ex-tropical Cyclone Wilma *two days of heavy rain affecting the north of the country*	815	$15,000,000	$19,800,000
2007.03.29	Northland Flooding *three days of heavy rain*	630	$9,400,000	$12,500,000
2017.03.07	North Island Heavy Rain and Flooding *seven days of heavy rain*	525	$6,100,000	$61,700,000
2016.11.10	Lower North Island flooding/wind *no description*	461	$5,400,000	$9,100,000
2007.07.09	Upper North Island Flooding and High Winds *three days of heavy rain*	323	$5,400,000	$68,600,000
2004.02.16	North Island Storm *six days of heavy rain*	1329	$5,000,000	$112,000,000
2015.06.20	New Zealand Storm *one week of intense rain in western areas of the South and North Islands*	440	$5,000,000	$41,500,000

Notes: This table contains information on the weather events in New Zealand between 2000 and 2017 which led to the highest total pay-out from New Zealand's public insurer (the Earthquake Commission (EQC)). Column (1) contains date information in YYYY.MM.DD form for the first day of the weather event. Column (2) contains the name and characteristics reported in the NZ Historic Weather Events Catalog (NIWA 2018a).. Column (3) contains the count of EQC "landslip/flood/storm" claims which are linked to an event matching the date in column (1). Column (4) contains the sum of EQC claim pay-outs expressed in inflation and GST adjusted 2017 NZ dollar values, and rounded to the nearest hundred thousand. Note the total number of EQC claims and EQC pay-outs are only lower-bound figures - these show the values linked to a single day. Column (5) contains the information from ICNZ (2018) for the amount paid by NZ private insurance following the full weather event. These are not inflation adjusted values. The web link for particular events from this historic weather database (where we obtain the name and characteristics of most of the events shown) is provided in Appendix 1.

Across most rows in Table 2, private insurance payments for the full event were higher than EQC first day of event pay-outs. However, one exception is the 2011 "Tasman-Nelson Heavy Rain" single day-long event, which triggered similar payment amounts from EQC and the private insurance companies. One peculiarity in this table is that private insurance payments do not have the same ranking as EQC claims pay-outs. In fact, the highest payment for a weather event made by private insurance companies (with a figure over $100 million), was the 2004 "North Island Storm", which is ranked 9th for EQC pay-outs. As discussed, this low correlation marks the specific and unique nature of EQC coverage, which does not necessarily align with the coverage provided by private insurers. [7]

6 Regional analysis including population and real estate data

We next incorporate in our geo-spatial analysis regional boundary data, population information, slope data and other geophysical variables (urban, rural, native and exotic forest cover, distance to water bodies such as rivers and lakes, distance to coasts, mangroves, swamps, and drainage courses). We utilise Land Information New Zealand (LINZ, 2018) topographic and hydrographic information. These geophysical characteristics have been associated with the properties by either computing the shortest distance to a feature (e.g. river) or by determining if a property sits on a particular topographic area. We also incorporate population data from Statistics NZ (2018). Specifically, we use the subnational population estimates by regional council for 2013.

Even though most claims are concentrated in cities, there are still a significant number occurring in rural areas. In fact, in our data, 34% of the claims are located outside the boundaries of what is defined as "residential areas". As noted in Table 1, only 72.3% of our claims are geo-referenced. For this reason, all results discussed in this section only consider as base a sub-sample of 18,930 claims.

6.1 Investigating public insurance distribution by region

We present information on weather related public insurance in New Zealand by region in Table 3**.** In Table 3 we separate the claim pay-out information by their region. We combine these with population and properties counts (to 2017). As seen in table 3, the Auckland and Wellington regions contain the largest number of claims in the country.

[7] It would therefore be of interest to examine the differential impact of climate change on the EQC and the private insurance sector, separately. For that, we would need more detail about the exposure of the insurance firms to past and present weather risk; this is data that, as of now, we cannot access.

Table 3: Investigating public weather-related insurance information between 2000 and 2017, across regions

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Region	No. of claims	Total pay-outs ($)*	Average pay-out per claim ($)	Population (2017)**	No. of claims per 1,000 people	Avg. claim pay-out per person ($)	No. of properties# (Oct 2017)	No. of claims per 1,000 properties	Avg. claim pay-out per property ($)
Northland	1363	17,876,533	13,116	175,400	7.77	102	65,672	20.75	272
Auckland	3132	43,135,685	13,773	1,657,200	1.89	26	471,337	6.64	92
Waikato	1409	14,212,697	10,087	460,100	3.06	31	166,605	8.46	85
Bay of Plenty	2263	20,651,354	9,126	299,900	7.55	69	108,015	20.95	191
Gisborne	194	3,528,657	18,189	48,500	4.00	73	15,927	12.18	222
Hawke's Bay	757	10,099,083	13,341	164,000	4.62	62	57,173	13.24	177
Taranaki	299	1,491,647	4,989	118,000	2.53	13	43,640	6.85	34
Manawatu-W.	969	7,874,467	8,126	240,300	4.03	33	89,724	10.80	88
Wellington	4781	32,585,246	6,816	513,900	9.30	63	173,705	27.52	188
West Coast	130	939,518	7,227	32,500	4.00	29	14,288	9.10	66
Canterbury	1118	7,303,199	6,532	612,000	1.83	12	220,365	5.07	33
Otago	894	7,328,313	8,197	224,200	3.99	33	88,168	10.14	83
Southland	22	59,347	2,698	98,400	0.22	0.6	38,826	0.57	1.5
Tasman	438	4,459,942	10,183	51,200	8.55	87	19,364	22.62	230
Nelson	932	12,587,389	13,506	51,400	18.13	245	19,031	48.97	661
Marlborough	229	2,984,624	13,033	46,200	4.96	65	20,411	11.22	146

Notes: This table contains information on weather related public insurance in New Zealand, by region, from New Zealand's public insurer (the Earthquake Commission (EQC)). Claim information is drawn from the set of claims between January 2000 and October 2017, Column (1) identifies the region, by regional council area in 2013, as sourced from Statistics NZ (2013). Column (2) contains the total number of these weather-related EQC claims which have been linked to a property in that region. Column (3) contains the sum of EQC claim pay-outs, for claims which are linked to geo-referenced properties, in NZ$ (deflated to 2017 values). Column (5) gives the regional population estimate in 2017, rounded to the nearest hundred, from StatsNZ (2018) data. Column (8) contains the number of properties, as of October 2017, in that region. This information is derived from the Corelogic (2018) dataset of 1,612,251 properties which were able to be intersected with the 2013 regional boundaries. Columns (4), (6), (7), (9) and (10) build off the other columns.

However, when looking at claims on a per capita basis, the Nelson region has double the number of claims per person than Wellington (the second highest rate). Nelson also leads the ranking in the number of claims received per total number of properties in the region. Northland, Bay of Plenty and the Tasman region also show a relatively high number of claims received when compared to the total number of properties in each region.

The total value of claims paid-out by EQC tells a different story. In this case, after Auckland and Wellington, the Bay of Plenty and Northland are the regions with the highest pay-outs received, followed by Nelson. However, Gisborne is the region with the highest average value of pay-out per claim (more than $18,000 received per claim, on average).

Looking at total pay-outs in a per capita and property basis, Nelson is still the region receiving the highest amount from EQC, with an average pay-out per person of $245 and per property of $661. Northland also received high amounts, with $272 per property, $42 more on average than the third most affected region, Tasman.

6.2 Do geophysical features correlate with weather-related claims?

Next, we analyse and compare the geophysical context of properties with and without claims. First, we look into how far properties are from water bodies. The vast majority of people in New Zealand live close to the coast. 90% of all residential properties are located less than 35km from the ocean.[8] In Table 4 we show the summary statistics of the distance to the ocean for properties with and without insurance claims. Compared to all properties in the country, properties with weather-related EQC claims are on average almost twice as close to the coast. From Table 4 one might infer that properties closer to the ocean are more likely to suffer EQC-insured damages from extreme weather events in New Zealand.

We next investigated the distance of properties to big rivers, small rivers (creeks) and other water bodies (lakes or swamps). Interestingly, in these cases, the medians are not very different between properties with EQC claims and properties without EQC claims (less than 300 meters across cases), although they are statistically different, based on Mann-Whitney and Pearson's chi-squared tests. These suggest that the medians of the two samples are statistically different at the 1% level. The medians are 3,525m vs. 3,790m for big rivers; 407m vs. 308m for small rivers; and 1,260m vs. 1,516m for lakes/swamps. Other geographic characteristics, such as distance from native or exotic forests, or mangroves, do not seem to be different across EQC and non-EQC properties.

8 Based on the Corelogic (2018) dataset of 1,612,251 properties.

Table 4: Distances of properties to the ocean

	(1)	(2)	(3)	(4)
		Distance to nearest body of water (km)		
	N	Mean	Median	Std. Dev.
All properties	1,612,251	11.185	2.609	19.246
Sample w/o weather-related EQC claims	1,595,552	11.240	2.631	19.285
Sample with weather-related EQC claims	16,699	5.881	1.371	14.081

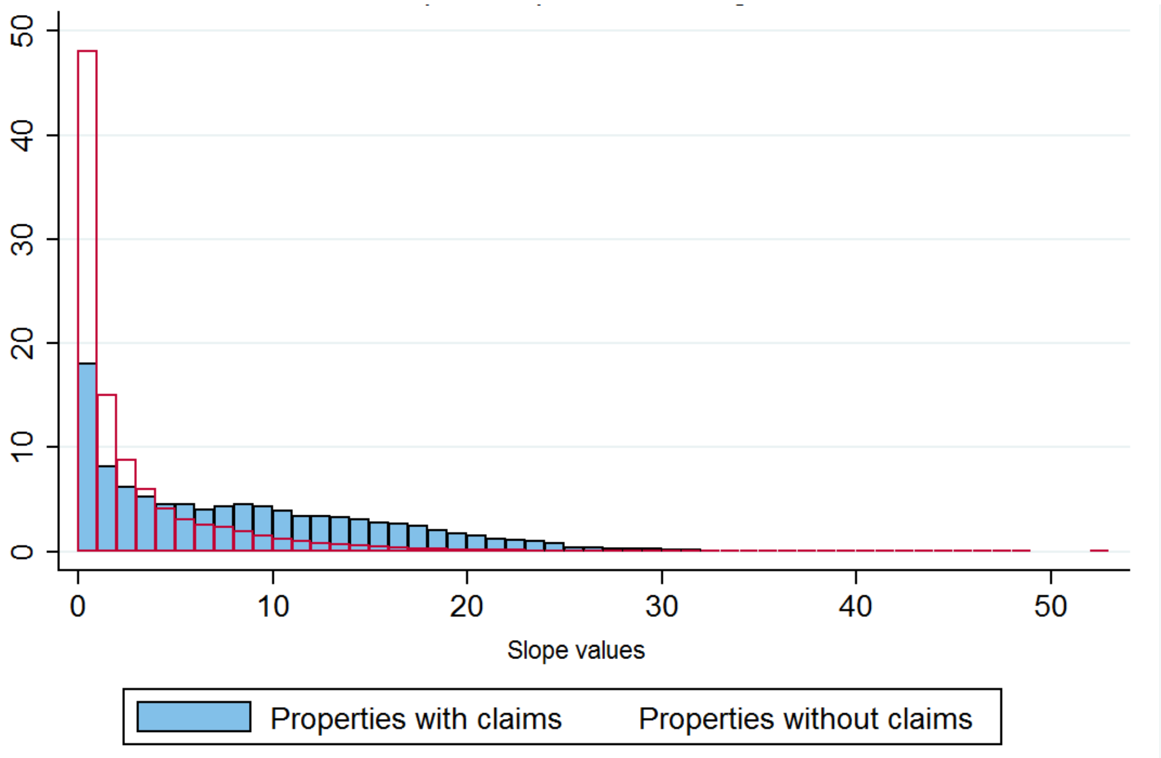
Notes: This table contains information on the distance in kilometres from properties to the shoreline. The number of EQC properties drops from the earlier counts because in many cases there are properties with more than one claim (triggered by a single event or triggered by different events). Authors' own elaboration with EQC and Corelogic (2018) data.

6.3 Does property slope correlate with weather-related claiming?

As we have the geo-location of every property in NZ, we also calculated the slopes on which these properties are located (in degrees). Flooding is usually associated with flatter areas, and most high flood-risk zones are very flat, while landslides are typical in steeper areas. If anything, we were expecting the distribution of slopes for properties with claims to be "double-humped"; concentrated on very flat and very steep terrain. This is not what we found. Figure 6 compares the average slopes for properties with weather-related claims compared to those without. On average, the properties with weather-related EQC claims are on steeper slopes. Almost 50% of properties without claims are on flat areas, while the same figure for those properties with claims is less than 20%.

A companion project, analysing in detail the claims records for Nelson, found evidence that most EQC claims are not associated with flood zones (as delineated on flood risk maps available for the Nelson region) (Pástor-Paz and Noy, 2018). Unfortunately, flood maps constructed with consistent methodology are not yet available for the whole of NZ, and any analysis based on the information we have is preliminary. At this point, these findings may suggest that flood maps that are available may not be able to accurately assist in identifying insurance liabilities associated with flooding.

Figure 6: Slopes of properties (in degrees) for buildings with and without claims



Note. The graph displays the distribution (in percent) of the slope values for properties with claims and without claims. The slope describes the gradient or steepness of the terrain, and is expressed in degrees, the latter one ranging from 0 to 90. The light-blue bars reveal that claims tend to happen in properties located in steep terrain, as opposed to properties without claims, which are mostly situated in relatively flat areas. Nevertheless, there are a few properties with claims sitting in flat areas. The slope was calculated using the method developed by Zevenbergen and Thorne (1987).

7 Investigating socioeconomic characteristics

7.1 Income and population growth for neighbourhoods with and without claims

Meshblocks (neighbourhoods) are the smallest unit for which the government publicly provides demographic data. In total, the country has more than 46,000 meshblocks (MBs) using 2013 boundaries. We use data on these meshblocks for the censuses of 2001, 2006 and 2013. Table 5 describes the summary statistics of the average meshblock in the country and of the average meshblock reporting at least one claim to EQC. The median income over the years is higher in meshblocks with EQC claims than the average meshblock in the country; providing some suggestive evidence that homeowners who make claims to EQC may have, on average, higher income. In Figure 7, we plot the distribution of the 2001 median personal (or household) income in meshblocks with EQC claims and for all meshblocks. As seen, the median income distribution of ‘EQC meshblocks’ is slightly shifted to the right from all meshblocks. In Table 6, we further explore this hypothesis, and disaggregate the distribution of meshblocks by income quintiles across the censuses of 2001, 2006 and 2013.

Table 5: Socioeconomic characteristics of meshblocks with and w/o EQC weather-related claims

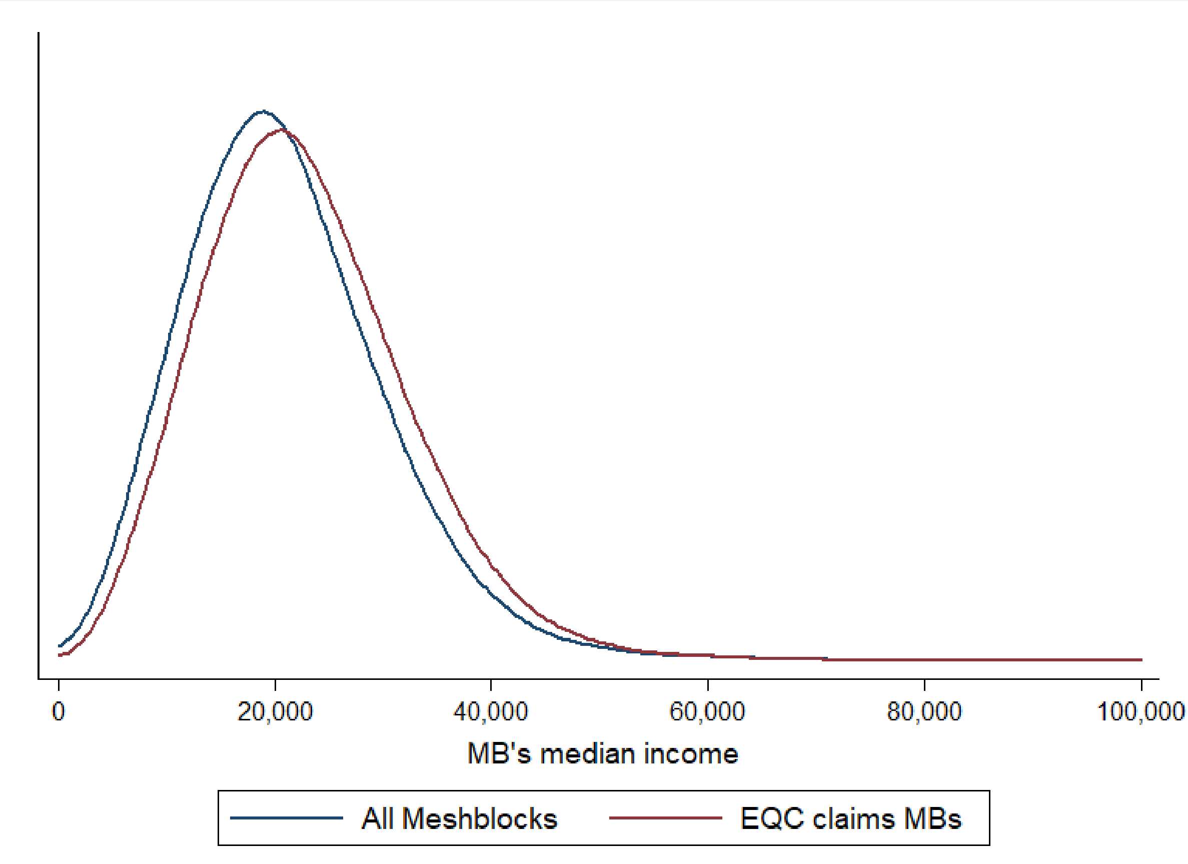
	(1)		(2)	
	Meshblocks containing properties with weather-related EQC claims		All meshblocks	
	mean	sd	mean	sd
Median income 2001	21,889	8,478	20,455	8,248
Median income 2006	27,855	9,575	25,973	9,567
Median income 2013	32,352	11,110	30,563	11,617
Population, 2001	102.4	61.9	80.2	62.9
Population, 2006	109.8	65.1	86.4	66.0
Population 2013	116.9	76.9	91.0	74.7
Population growth (%), 2001-2006	17.9	124.0	26.8	246.8
Population growth (%), 2006-2013	13.7	108.5	15.4	204.6

Notes: This table contains information on the meshblocks that have or have no properties with weather related public insurance claims in New Zealand. Claim data is provided by New Zealand's public insurer (the Earthquake Commission (EQC)). This table refers to claim information drawn from the set of claims between January 2000 and October 2017. The meshblock level census information is sourced from StatsNZ (2018) and is available for Census years only. Income refers to median family income and expressed in thousands of $NZ. The population is given by "place of usual residence". NB: the calculated means are not weighted by population. The number of observations for all meshblocks (MBs) varies as it is supplied by StatsNZ, between 46,134 to 46,629. There are 4,228 meshblocks containing properties that have ever lodged weather-related EQC claims.

In Table 6, the number of total EQC claims across the three census periods (we aggregated claims by year ranges as shown in the table) are disproportionally concentrated in the top-two highest quintiles, representing 52%, 55% and 50% of the total received claims for the three periods. This is remarkably high if we consider that the total number of properties located in these suburbs is only around 36-39% of the total number of properties in the country. In the table we also provide the distribution of total pay-outs made by EQC across meshblocks. The concentration of pay-outs is very similar to the concentration of the number of claims. In this case, pay-outs in the top-two income quintile meshblocks capture around 52-53% of the total pay-outs made by EQC in the respective periods. Similarly, Owen and Noy (2017) find that the distribution of EQC claim pay-outs after the Canterbury Earthquakes of 2010-2011 was skewed toward households with higher income and wealth. It is important to note that homeowners do not pay a premium for EQC land coverage (and premiums paid for building and contents coverage are practically identical across all properties).

In Table 5, it can be observed that meshblocks reporting at least one EQC claim since 2000 have relatively higher population than the average. This is more in line with our expectations, as population is closely aligned with exposure, and was already noted by the high concentration of claims in Auckland, Wellington and Christchurch. However, it is interesting to note that EQC meshblocks tend to have lower population growth than the average meshblock – especially in the period 2001-06. To further explore this last finding, we look at the distribution of claims (total number and pay-outs) across the meshblocks given their population growth. For this we looked at the quintiles of meshblocks given population growth between 2001-06 and 2006-13, as shown in Table 6. Results for the distribution of EQC claims across high/low population growth meshblocks do not differ importantly from the distribution of properties or the same meshblocks across quintiles, suggesting that claims lodgements and total pay-outs are not necessarily more (or less) common in expanding meshblocks. This may suggest that, at the very least, the additional exposure that is being generated by increased population is not heavily biased toward the high at-risk areas. We plan to investigate this issue further in follow-up work.

Figure 7: Median income distribution across meshblocks in 2001



Notes: This figure shows the distribution of median family income in 2001. Each line corresponds to a sample: either for all meshblocks, or for those meshblocks with weather related public insurance claims in New Zealand between Jan 2000 and Oct 2017. Claim data (and thus property sample and meshblock sample) is provided by New Zealand's public insurer (the Earthquake Commission (EQC)). The meshblock level median income information is sourced from StatsNZ (2018) and is shown for the Census year 2001 only. There are around 46,000 meshblocks in total. The number of observations for all meshblocks (MBs) varies as it is supplied by StatsNZ, between 46,134 to 46,629. There are 4,228 meshblocks containing properties that have lodged weather-related EQC claims between Jan 2000 and Oct 2017. The red line shows the distribution of median income reported in the 2001 Census for meshblocks containing properties which have made weather-related EQC claims. Note charts for median income in 2006 and 2013 are structurally similar to this one.

Table 6: Claims and total pay-outs across meshblocks, by income quintiles

	(1)	(2)	(3)	(4)	(5)	(6)
	Income quintile	Income range ($)	Meshblocks (%)	Dwellings (%)	Claims (%)	Pay-outs (% of total)
Census 2001 data – EQC claims from 2000 to 2003	1	<= 13.8	20.74	17.08	13.16	13.37
	2	13.9 – 17.5	24.87	27.04	21.13	14.86
	3	17.6 – 20.8	14.49	16.58	13.70	20.22
	4	21.0 – 26.3	20.28	21.23	22.44	22.01
	5	>=26.4	19.62	18.07	29.58	29.53
Census 2006 data – EQC claims from 2004 to 2008	1	<= 18.3	20.69	17.23	9.89	10.17
	2	18.4 – 22.5	21.35	22.33	20.47	15.40
	3	22.6 – 27.5	23.26	24.42	14.39	21.68
	4	27.6 – 32.5	16.41	17.61	23.65	23.87
	5	>= 32.6	18.30	18.41	31.60	28.88
Census 2013 data – EQC claims from 2009 to 2017	1	<= 21.3	20.65	16.75	11.66	12.70
	2	21.4 – 26.7	19.43	21.56	21.88	14.43
	3	26.8 – 32.5	23.85	25.75	16.18	20.56
	4	32.7 – 38.8	16.78	18.07	23.65	25.29
	5	>= 39.0	19.29	17.87	26.63	27.01

*Note*s: This table shows information at the meshblock level by quintiles of median family income in a particular census year in New Zealand. The upper panel draws from a dataset made up of 2001 Census data and information on public weather-related insurance claims from 2000-2003. The middle panel draws on the 2006 Census and claims between 2004 and 2008. The lower panel draws on the 2013 Census and claims between 2009 and 2017. Column (3) shows the percentage of those meshblocks with weather related public insurance claims between Jan 2000 and Oct 2017) by income quintile. Claim data is provided by New Zealand's public natural hazard insurer (the Earthquake Commission (EQC)). The meshblock level median income information is sourced from StatsNZ (2018). There are around 46,000 meshblocks in total. The number of observations for all meshblocks (MBs) varies as it is supplied by StatsNZ, between 46,134 to 46,629 There are 4,228 meshblocks containing properties that have lodged weather-related EQC claims between Jan 2000 and Oct 2017. Income refers to median family income in thousands of $NZ.

Table 7: Claims and total pay-outs across meshblocks, by population growth quintiles

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Population growth (quintile)	Population growth (%)	Meshblocks (%)	Dwellings (%)	Claims (%)	Pay-outs (% of total)
2001 and 2006 Census data – EQC claims from 2004 to 2008	1	<= -9.46	20.01	14.69	17.13	11.51
	2	-9.44 to 0	28.03	28.18	30.42	12.98
	3	0.45 to 7.14	12.28	16.07	15.56	22.70
	4	7.22 to 20.45	19.69	22.35	22.17	25.98
	5	>= 20.50	19.99	18.71	14.72	26.83
2006 and 2013 Census data – EQC claims from 2009 to 2017	1	<= -12.5	20.26	12.97	14.28	16.09
	2	-12.4 to -1.82	19.77	22.85	23.56	17.62
	3	-1.81 to 4.88	20.01	20.18	21.55	20.62
	4	4.90 to 17.65	19.98	23.24	23.18	21.84
	5	>= 17.70	19.98	20.76	17.44	23.83

Notes: This table shows information at the meshblock level by quintiles of population growth between census years in New Zealand. The upper panel draws from a dataset made up of 2001 and 2006 Census data and information on public weather-related insurance claims from 2004-2008. The lower panel draws on 2006 and 2013 Census data and on claims between 2009 and 2017. Column (3) shows the percentage of those meshblocks with weather related public insurance claims in New Zealand between Jan 2000 and Oct 2017) by population growth quintile. The meshblock level median income information is sourced from StatsNZ (2018). There are around 46,000 meshblocks in total. The number of observations for all meshblocks varies as it is supplied by StatsNZ, between 46,134 to 46,629, There are 4,228 meshblocks containing properties that had lodged weather-related EQC claims between Jan 2000 and Oct 2017. Income range are median family income in thousands of $NZD. Claim data is provided by New Zealand's public natural hazard insurer (the Earthquake Commission (EQC)).

8 Discussion and conclusions

This paper describes the insurance support provided by the New Zealand Earthquake Commission (EQC) after extreme weather events in the last 18 years. Data on EQC claims are used to describe location characteristics, the weather events triggering high numbers of claims, and the geophysical and socioeconomic characteristics of the neighbourhoods from where claims come.

Our analysis shows that Northland and the Bay of Plenty in the North Island are the regions with the highest proportion of people and properties negatively affected by weather disasters, while Nelson and the Tasman regions are the most affected regions in the South Island. We also show how five extreme weather events (four of which happened in these regions) account for about a third of the total pay-outs made by EQC for weather events since 2000.

We find that, even though most properties in New Zealand are located not far from the coast, properties reporting claims to EQC are located even closer. While the average property in NZ is approximately 11km away from the coast, the average property lodging a claim to EQC after a weather event, is only about half the distance away. Properties closer to the coast are therefore much more likely to be a potential financial liability to EQC.

We also explore the socio-economic characteristics of meshblocks from whence claims come, and contrast these to the distribution of income across all meshblocks in the country. We find that, even though claim numbers are highly correlated with population across meshblocks, there is no clear correlation between claim numbers (or pay-outs) and population growth. In other words, findings so far suggest that claims are not more likely to come from expanding meshblocks, than from areas without major population change.

Finally, we show that more EQC claims tend to come from meshblocks with higher median income. We find that meshblocks in the top-two income quintiles account for more than half of the total claims and pay-outs made by the EQC. This finding suggests that after extreme weather events, higher income families make more use of EQC insurance coverage than the average New Zealand family. The reasons for this increase in EQC pay-outs associated with higher income households are not yet clear. They could be associated with better access to the system, higher exposure due to location choice, or higher damages caused by higher asset values (e.g. larger residential land areas).

The findings described in this paper can also be considered in the context of discussions initiated by the Parliamentary Commissioner for the Environment, which proposes to institute an EQC-like scheme for dealing specifically with sea-level rise and flooding (PCE, 2015). It may also be useful for current discussions about proposed revisions to the Earthquake Commission Act (1993) and the Insurance Law Reform Act (1985). This paper is the first in a series of projects which ultimately aim to project the financial liability from climate change for EQC and better understand the role of the EQC in climate adaptation.

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Appendix

Appendix Table A

Date of event	Name of event - characteristics	NIWA's weather catalogue link
2005.05.18	Bay of Plenty and Waikato Flooding – heavy rain	hwe.niwa.co.nz/event/May_2005_Bay_of_Plenty_and_Waikato_Flooding
2008.07.26	North Island Weather Bomb - high winds, seas and rainfall in several regions of the country	hwe.niwa.co.nz/event/July_2008_North_Island_Weather_Bomb
2011.04.25	Hawke's Bay Flooding – four days of heavy rain	hwe.niwa.co.nz/event/April_2011_Hawkes_Bay_Flooding
2011.12.14	Tasman-Nelson Heavy Rain and Flooding	hwe.niwa.co.nz/event/December_2011_Tasman-Nelson_Heavy_Rain_and_Flooding
2011.01.29	Ex-tropical Cyclone Wilma - two days of heavy rain affecting the north of the country	hwe.niwa.co.nz/event/January_2011_Upper_North_Island_Storm
2007.03.29	Northland Flooding – three days of heavy rain	hwe.niwa.co.nz/event/March_2007_Northland_Flooding
2017.03.07	North Island Heavy Rain and Flooding - seven days of heavy rain	hwe.niwa.co.nz/event/March_2017_North_Island_Heavy_Rain_and_Flooding
2016.11.10	Lower North Island flooding/wind	N/A
2007.07.09	Upper North Island Flooding and High Winds – three days of heavy rain	https://hwe.niwa.co.nz/event/July_2007_Upper_North_Island_Flooding_and_High_Winds
2004.02.16	North Island Storm - six days of heavy rain	hwe.niwa.co.nz/event/February_2004_North_Island_Storm
2015.06.20	New Zealand Storm – one week of intense rain in western areas of the South and North Islands	hwe.niwa.co.nz/event/June_2015_New_Zealand_Storm

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