The Unfortunate Regressivity of Public Natural Hazard Insurance: A Quantitative Analysis of a New Zealand Case

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Abstract

Natural hazard insurance is almost always provided through public-private partnerships. Given the dominant role of the public sector, it is surprising that equity issues have not faced more scrutiny with respect to the design of hazard insurance. We provide a detailed quantification of the degree of regressivity of the New Zealand earthquake insurance program – a system that was designed with an egalitarian purpose. We measure this regressivity as it manifested in the half a million insurance claims that resulted from the Canterbury earthquakes of 2011. As in other cases, this can be remedied with modifications to the program's structure.

JEL-Codes: D300.

Keywords: insurance, redistribution, regressivity, tax.

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1. Introduction

Private natural hazard insurance markets seldom succeed in providing widespread coverage (Kunreuther and Pauly, 2009; Cuong, Kusuma and Noy, 2017).[1] There are multiple examples of failed attempts to provide financial natural hazard risk transfer (insurance) through private markets, flood and earthquake insurance in the United States being two prominent cases. In fact, no country has a private market for flood insurance that provides affordable and accessible cover for high-risk households without some form of government involvement (ABI 2011).

A good insurance system incentivises risk reduction and enables the insured party to take on beneficial and profitable business risks and invest ex ante; ex post, it allows the insured party to evade at least some of the financial loss, avoid destitution, and recover more quickly and more fully. O'Neill & O'Neill (2012) further argue that insurance should guarantee the security of required basic goods, according to social justice criteria, *independently of the risks involved and the risk-taking by individuals* — housing being a prime example. From a communitarian rather than an individualist perspective, the inability of some households to rebuild their pre-disaster lives inflicts additional harm on the rest of the community. But, even from an individualist perspective, if there is no provision of natural hazard insurance by the private market, governments find a political rationale for intervention to facilitate insurance coverage for all. Governments can choose to pursue this aim by either insuring directly or subsidizing the private insurance sector, and have chosen to do so in many countries.[2]

Given the complexity of insuring extreme risks, private-sector insurers and governments tend to cooperate in public-private-partnership (PPP) schemes. Paudel (2012) provides nine recommendations for designing such PPP schemes. His recommendations include: mandatory participation; adequate enforcement to ensure compliance; public responsibility for the extreme risk (the catastrophic end) of the insured risk, private sector administering of policies; public provision of subsidies through, for example, tax exemptions; public investment in risk mitigation; a (publicly provided) detailed assessment and mapping of risk; and the provision of financial incentives for policyholders to take risk mitigation measures.

Most disaster economists also argue that insurance premiums should be risk based (e.g., Bin, Bishop & Kousky, 2010 and Kunreuther, 2015). Risk-based insurance premiums signal to residents and businesses the hazards they face and enable insurers to lower premiums for properties for which steps have been taken to reduce risk. Risk-based premiums,

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[1] Natural hazard insurance is also known as catastrophe insurance, disaster insurance, or natural disaster insurance, depending on the context. We use natural hazard insurance for specificity.
[2] Belgium, France, Japan, New Zealand, Spain, Switzerland, Turkey, UK, and the USA to name only a few.

however, do raise equity concerns, and there is some recognition that a fully risk-sensitive insurance regime may be socially or politically unacceptable if it imposes very high costs on some groups (Houston et al., 2011).[3]

Given the dominant role of the public sector in the provision of natural hazard insurance, and the evident concern worldwide about growing income and wealth inequality, it is surprising that equity issues have not faced more scrutiny with respect to publicly provided natural hazard insurance. For example, this aspect of the recently launched UK government FloodRe program has received almost no attention, in spite of the potentially very regressive structure of that program.

In this paper, we provide—possibly for the first time—a detailed quantification of the degree of regressivity of a public natural hazard insurance scheme. We chose to focus on the New Zealand (NZ) earthquake insurance scheme for four main reasons: (1) The availability of claims records after a large event (the series of Canterbury earthquakes in 2010–2011 that led to a very large number of claims); (2) The well-established success of this program in achieving wide-spread coverage – the Canterbury earthquakes were the most insured large-scale series of events ever[4]; (3) The egalitarian aim of this scheme (all dwellings pay identical premiums); and (4) The comparatively egalitarian distributional policy of past and present NZ governments.

In spite of both (3) and (4), we find that the current NZ scheme is strongly regressive, and we report on the exact extent of this regressivity as it manifested in the half a million insurance claims that resulted from the Canterbury earthquakes. While an extensive tabulation of schemes in other countries has not been undertaken, we suspect that most of these schemes are even more regressive. We point to this by noting the basic characteristics of a number of schemes in Table 1. In particular, we note the components of the program that determined the degree of its regressivity: what perils are covered, who is covered, whether the indemnity is limited, and how premiums are set. We end this paper by suggesting that this regressivity can be easily remedied with simple modifications to the current structure of the program.

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[3] Kunreuther (2015) suggests that to address issues of equity and fairness, homeowners who cannot afford insurance could be given vouchers tied to loans for investing in loss reduction measures, but this kind of voucher program is yet to be implemented anywhere.
[4] The three highest cost earthquakes in the Canterbury sequence are among the top 10 costliest earthquakes for 1980–2015 (by insured losses). Relative to damages, these events were at least twice as well insured as any of the others on the list (MunichRe, 2016).

Table 1: Public and Public-Private natural hazard insurance systems for personal property

Country	System name	Compulsory	Market penetration	Policy indemnity limit	Premium-setting	Hazards covered
Austria	Obligatorium	No	10-25%[5]	No	Flat (%)	NH[6]
Belgium	WN	Partially[7]	>95%	Yes (nominal)	Risk-based	NH
Denmark	Storm Council	Partially[8]	Unknown	No	Flat (nominal[9])	Flood[10]
France	CatNat/CCR[11]	Partially[12]	92%	Yes (total insured value)	Flat	NH
Iceland	ICI[13]	Yes	100%	No	Flat (%[14])	NH[15]
Japan	JER[16]	Partially[17]	20%(46%[18]	Yes (damage-based)	Risk based	EQ & related
Norway	NNPP[19]	Partially[20]	Unknown	No	Flat (%SI[21])	NH[22]
NZ	EQC[23]	Partially[24]	~90%[25]	Yes (nominal[26])	Flat	NH
Romania	PRAC	Yes	100%	Yes (nominal)	Flat[27]	NH[28]

[5] CCS (2008) Gaschen et al. (1998) Bouwer et al. (2007)

[6] Storms, hail, snow load, flooding, high ground water, EQs and subsidence. NH denotes natural hazards.

[7] With fire insurance

[8] With fire insurance, and compulsory coastal flooding cover

[9] DKK 20 per year as of 2008 (CCS, 2008).

[10] Must be caused by seawater by a manifest rise in sea level from a cyclonic event.

[11] Caisse Centrale de Réassurance, see https://www.ccr.fr/activites/reassurances-et-fonds-publics/catastrophes-naturelles

[12] With property insurance

[13] Iceland Natural hazard insurance, see https://www.vidlagatrygging.is/en/about-the-ici/

[14] 0.25 per thousand of premium, collected by the fire insurance provider.

[15] EQs, volcanic eruptions, avalanches, landslides and floods.

[16] Japan Earthquake Reinsurance Co Ltd, see http://www.mof.go.jp/english/financial_system/earthquake_insurance/outline_of_earthquake_insurance.html

[17] Loosely tied to fire insurance.

[18] Nguyen (2012), cites "Non-Life Insurance Rating Organization of Japan, http://www.nliro.or.jp/english/data.html"

[19] Norwegian Natural Perils Pool.

[20] With fire insurance.

[21] 0.11 per thousand dollars of sum insured.

[22] Flood, storm and tempest, landslide, avalanche, EQ, and volcanic eruption.

[23] Earthquake Commission, see http://www.eqc.govt.nz/

[24] With fire insurance

[25] EQC (2011)

[26] Properties are insured to replacement value, but the EQC payout per dwelling is capped at 100K, after which the private insurer makes up the difference.

[27] 10 or 20 annually, determined by construction style.

[28] EQ, flood, landslide and indirect losses caused by these perils.

Country	System name	Compulsory	Market penetration	Policy indemnity limit	Premium-setting	Hazards covered
Spain	CCS[29]	Partially[30]	>80%	Yes (total insured value)	Flat	NH
Switzerland	KGVs	Yes[31]	>95%	No	Flat	NH
Taiwan	TREIF[32]	Partially[33]	32.92%[34]	Yes (replacement)	Partially risk based[35]	EQ & related[36]
Turkey	TCIP[37]	Partially[38]	20%	Yes (nominal[39])	Risk based	EQ & related[40]
UK	FloodRe[41]	No	85%[42]	Varied[43]	Flat[44]	Flood
USA	NFIP[45]	Partially[46]	~50%[47]	Yes	Partially risk based	Flood
USA - California	CEA[48]	No	9.7%[49]	No	Partially risk based[50]	EQ & related

[29] Consorcio de Compensación de Seguros

[30] With property insurance

[31] In all Swiss cantons, there is compulsory insurance for house owners: all Swiss house owners must insure against natural hazards and alpine risks such as storms, hail, flood, avalanches, snow loads, landslides and rock falls, in addition to insurance against fire. (Schwarze et al. 2010)

[32] Taiwan Residential Earthquake Insurance Fund, see http://www.treif.org.tw/eindex.aspx

[33] All residential fire insurance policies issued by insurers must automatically be extended to cover residential EQ risk.

[34] As of 2016, according to TREIF http://www.treif.org.tw/e_contents/B_financial/B1.aspx

[35] Unified annual premium rate of NT$ 1,459 (85% pure risk and 15% loading) (CCS 2008).

[36] Fire, explosion, landslide, land subsidence, land movement, land rupture, tidal wave, surge and flood caused by earthquake and resulting in total or constructive total loss (uninhabitable or whose repair cost is greater than 50% of the rebuilding cost).

[37] Turkish National Natural hazard insurance Pool, see http://www.tcip.gov.tr/

[38] Compulsory for some dwellings.

[39] Maximum sum insured NTL 110.000 (CCS 2008), otherwise policy sum insured determined by multiplying square meter costs with gross square meter area of dwelling.

[40] EQs and fire/explosion/landslides as a result of EQs.

[41] Flood RE, see http://www.floodre.co.uk/

[42] Of insurers participating in the pool (Surminski, 2017).

[43] Appears to be at discretion of the insurer.

[44] Based on council tax banding, not risk.

[45] National Flood Insurance Program, see https://www.fema.gov/national-flood-insurance-program

[46] For properties with federal mortgage in flood plain

[47] In the 1/100 floodplain

[48] California Earthquake Authority, see https://www.earthquakeauthority.com/

[49] As of 2015 (Marshall 2017).

Country	System name	Compulsory	Market penetration	Policy indemnity limit	Premium-setting	Hazards covered
USA - Florida	Citizens[51]	No	8.5%	Yes (total insured/property value)	Partially risk based[52]	Windstorm
USA - Texas	TWIA[53]	No	57.2%[54]	Yes (% of replacement cost)[55]	Partially risk based[56]	Windstorm

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[50] Factors include the insured value of the home, location, construction year, construction and foundation types, number of stories, and the customer's coverage choices.

[51] http://www.citizensfla.com/

[52] Designed for "actuarial soundness" including some risk modelling (Kousky, 2011)

[53] Texas Windstorm Insurance Association, see https://www.twia.org/

[54] McAneney et al. (2013)

[55] See https://www.twia.org/itv/

[56] "Actuarially sound" but not strictly risk based. (McAneney et al., 2013)

2. Regressivity and Natural hazard insurance

Fairness has long been discussed in the evaluation of taxation (e.g., Simons, 1938; Goode, 1980). Economists have generally recognised two principal concepts of fair taxation: benefit, and the ability to pay. From a benefit perspective, taxes should be levied such that benefits received by the payers are proportional to their tax burden. Under this concept of fairness, there is little scope for redistribution. An example thereof is motor fuel excise tax, which is used to pay for roadway construction and maintenance. The ability to pay principle focuses only on the cost side, while ignoring the distribution of benefits. It views taxation as imposing a cost that should be allocated in such a way that it taxes those with equal ability to pay equally (horizontal equity), and imposes a greater burden on those with greater ability to pay (vertical equity).[57]

The concept of regressivity was originally applied to income tax systems. As defined in Kakwani (1977), if $T(x)$ is the tax paid by an individual with income x, the tax system is proportional when the elasticity of T with respect to x is equal to one for all x, the tax system is progressive when the elasticity exceeds one, and regressive when the elasticity is less than one. This is equivalent to saying that a tax system is progressive, proportional, and regressive when the marginal tax rate is greater, equal, and less than the average tax rate, respectively.[58]

Musgrave and Thin (1948) created a more universal measure of progressivity by comparing the inequality of income distributions pre-tax and post-tax. A progressive tax system will then create a decrease in income inequality, while regressive tax rates will be reflected by increases in income inequality. The authors were able to conclude that if the Gini index is used to measure inequality, the ratio of the Gini indices of the before-tax and after-tax incomes provides a single measure of tax progressivity.[59]

Previous work has looked at the regressivity of explicit tax schemes; examples include "sin" taxes[60] and carbon taxes.[61] This type of measurement of progressivity has also been used to

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[57] Ability to pay is generally measured by annual income. There is no agreed upon standard to determine what vertical differentiation in tax liabilities is most fair (Joint Committee on Taxation, 2015).

[58] Slitor (1948) used this type of definition to propose a measure of progression: $dt(x)/dx = [m(x) - t(X)]/x$; where $t(x)$ is the average tax rate at the income level x and $m(x)$ is the marginal tax rate at that level of income.

[59] Kakwani (1977), however, pointed out that by doubling the tax rates at all income levels, the tax progressivity would mechanically increase when using the Musgrave-Thin ratio. This is problematic because progressivity (or regressivity) is supposed to measure the deviation of a tax system from proportionality. Kakwani proposes to use the Gini index only to measure the distributional effects of taxation, and presents an alternative measure using the Lorenz Curve to create a measure that accounts for both the distributional and proportional elements of a tax system.

[60] Poterba (1991a), Lyon & Schwab (1991), Bento et al. (2012), and Borren & Sutton (1992).

[61] Wier et al (2005), and Poterba (1991b).

study implicit taxes and subsidies. For example, Davis and Knittel (2016) investigate whether fuel efficiency standards are regressive, and Johnson (2006) looks at public spending on higher education.

While the potential distributional aspect of public natural hazard insurance has been noted in the literature, the practical implications in terms of benefits (expected payment of claims) relative to costs (premiums paid) have not previously been quantified.

Ben-Shahar and Logue (2015) examine Florida's state-owned Citizens' Property Insurance Corporation ("Citizens") and its coverage for wind-damage (hurricanes). Their work relies on Citizens' own calculations of the actual risk it takes on when providing insurance, and on the premiums it charges. They find that the higher subsidies are provided for areas incurring more risk, and that these areas are generally (statistically) wealthier, most likely because they are located closer to the coast. A second paper that investigates a similar program, by Bin, Bishop, and Kousky (2012), studies the U.S. National Flood Insurance Program (NFIP). It focuses on the departure from the proportionality measure of progressivity. A progressive departure from proportionality requires that every premium decile be no larger than the corresponding income decile. The authors show that the departure-from-proportionality index is not significantly different from zero for premiums, implying they are proportional to income. However, they conclude that NFIP payments are progressive, but they consider premiums and payments separately, and note that neither effect is extreme and that these effects are smoothed over time.

Howard (2016) examines the net social benefits of the NFIP, using data on premiums, claims, policies, and grants from 1996–2010. In his more comprehensive analysis he finds that this system is "moderately regressive." According to these three analyses of the natural hazard insurance in the U.S., it is plausible that the distributional aspect arises solely from the differentiated exposure of wealthier households, due to their location on the coasts and the focus on hurricane damage, as many of the NFIP claims arise from storm-generated wave surges. In many cases, and in most countries, however, it is generally the poorer households that are more exposed (Karim and Noy, 2016).

Surminski (2016) and Davey (2015) discuss various distributional aspects of FloodRe, the UK's new flood reinsurance programme that is designed to maintain affordably priced flood insurance. Both papers identify several ways in which FloodRe may have distributional consequences, but do not quantify them. O'Neill & O'Neill (2012) discuss flood insurance in the UK (before the launch of FloodRe) and argue for a solidarity-based scheme on fairness grounds, acknowledging that risk based premiums would unfairly penalise households who could not reasonably be found to have chosen to live in flood prone areas of their own will. They note that "choice is voluntary only if it can be reasonably foreseen and the agents have real and acceptable alternatives to it." This statement raises interesting equity questions, as

it is likely that those households facing higher risks are wealthier, in which case the fairness principle they advocate may lead to the insurance transferring risk from rich to poor households, and thereby the poor subsidising the rich.[62]

Here, we quantify the distributional effect of public natural hazard insurance in a NZ case, and identify the unfortunate regressivity of one of the theoretically most equitably designed public natural hazard insurance systems globally. It is easy to argue that many of the other public natural hazard insurance systems established globally (see Table 1) are likely to be at least as regressive.

The next section describes the data we use for our quantitative analysis. Section 3 explains the methodology, in Section 4 we explain our results, and Section 5 concludes.

3. Data

In NZ, public natural hazard insurance is provided to residential homeowners by the Earthquake Commission (EQC). In order to access this insurance, homeowners need only have private fire insurance (which over 90% do). The public EQC premiums are collected through private fire insurers, and are identical for building cover of all dwellings insured for more than NZ$ 100,000 (as almost all are).

To fully appreciate the role EQC plays, we must consider how it developed. In 1906 San Francisco was hit by a devastating earthquake, hitting German insurers especially hard. In the wake of this event, much of the global insurance industry responded by excluding earthquake and related fire damage from their policies (Henderson, 2010). In 1931, NZ was struck by an earthquake centered on Napier. At this time, private earthquake insurance was available in NZ, but was voluntary (NZNSEE, 1993). Then, in 1937, with World War II looming, war damage was excluded from most private insurance contracts. Again, in 1942, NZ was hit by another damaging earthquake not far from the capital, and in 1944, the Earthquake and War Damage Commission was established; it is the historical precursor to the EQC.[63]

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[62] The question of fairness becomes even more complicated if the hazard being insured is climate-related and its frequency or intensity is changing because of climate change. In this case, insurance systems provide a certain degree of collective protection with some distributional consequences, but the insured event was outcome of actions for which there is an uneven, shared responsibility. For flooding, it is the outcome of actions for which those who are most vulnerable often are at least hypothetically the least responsible. There is a double injustice if those with low incomes who are least responsible for anthropogenic global warming are faced with the largest burdens of damages (Thumim et al., 2011, Lindley et al., 2011).

[63] Part of the motivation for this was the slow rates of repair following the 1931 and 1942 events (NZ Treasury 2015). In the years that followed NZ was hit by a number of disasters including an earthquake triggered tsunami in 1944, an earthquake in 1968 and a major landslip in 1979. The Earthquake Commission Act of 1993 redesigned the scheme. A major development was the phase-out of commercial properties. It also amalgamated the War Damage and Earthquake Fund and the Disaster and Landslip Fund as the Natural Disaster Fund. This is the fund EQC draws from to pay out on claims.

The EQC currently provides three forms of insurance cover to residential property owners: structure, land, and contents. These are insured to replacement value against natural hazards such as earthquake/tsunami, volcanic eruption, and landslip. Since 1980, out of 543,531 claims, 94.9% have been related to earthquakes. The cover for residential buildings provides the first NZ$ 100,000 of replacement value for each insured dwelling.[64] If the loss is greater, the private insurer is responsible for any over-cap repair costs. As we will focus the analysis below exclusively on structural damage claims (and not on contents or land), we only describe this aspect of EQC policy.[65] For each NZ$ 100 of property insured by the EQC, a levy is charged by the private insurer and sent to EQC. These premiums had been set at 0.0005% of the amount insured in 1993, and were tripled after the Canterbury earthquakes of 2010–11 to 0.0015%. More than 99% of homes are valued at more than NZ$ 100,000, so that in effect all pay the same amount to EQC for the building insurance it provides (NZ$ 150 per annum).[66]

In order to quantify the regressivity of the EQC building cover, we required a measure of the benefit delivered by the EQC scheme. There is value in the certainty of knowing one is insured regardless of whether that insurance is ever required, and some value in the indirect facilitation of the over-cap private natural hazard insurance market. Our analysis assumes that this value is equal for all participants in the scheme and we therefore ignore it. For the purposes of this analysis, the benefit is defined as actual payout to the owner for disaster damage. This is a plausible measure since virtually all homes in Christchurch were damaged in the Canterbury earthquake sequence, and if anything, homeowners of weaker socioeconomic backgrounds were located closer to the epicentre of the earthquake. Thus, the redistributive question is: Have wealthier homeowners received more money from EQC for building repair than their less well-off counterparts?

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[64] A multi-unit residential building covered for fire damage would be insured through EQC for the first NZ$ 100,000 times the number of dwellings in the building.
[65] The details about land cover, uniquely covered in NZ, are significantly more complicated.
[66] Recall the building cover from EQC is capped at NZ$ 100,000 per dwelling.

To answer this question, we combined two datasets: EQC insurance claim data from the Canterbury Earthquake series of 2010–2011,[67] and census data from Statistics NZ. Table 2 reports the summary statistics of the dwelling-level dataset we used in our analysis.

Table 2: Summary Statistics - Property level data for the Canterbury EQ Series Dataset

	(1)	(2)	(3)	(4)
VARIABLES	mean	sd	min	max
Total Dwelling Payout	45,774	58,207	0	358,381
Dwelling Payout / # of Claims	26,254	31,503	0	344,101
Assessed Bldg Repair Costs	63,370	139,215	0	1.498e+07
# claims made on that address	1.538	0.734	1	7
# dwellings claimed for on that address	1.066	1.014	1	102
Building Value 10	319,991	240,102	43,844	2.091e+07
Dwelling adjusted Building Value 2010	303,682	150,233	1,120	1.752e+07

Note: This table contains summary statistics for the 94,687 properties for which we have insurance claim data relating to the Canterbury Earthquake Series. There were five earthquakes associated with a significant number of payments (04/09/2010, 26/12/2010, 22/02/2011, 13/06/2011, 23/12/2011). Most are associated with the first and third events. 7.2% of dwellings are in the rural meshblocks. All monetary amounts in NZ$.

We also made use of Statistics New Zealand data—it provided meshblock level information from the New Zealand Census, conducted in 2001, 2006 and 2013.[68] The average number of people residing in a meshblock in Canterbury was about 105. We were able to match each property to a meshblock, which allowed us to match the property-level data to the meshblock-level socioeconomic data available from the Census. For our initial analysis, we included a number of explanatory variables generated from the 2006 Census (since it preceded the earthquakes). We used data pertaining to the personal and household sections of the census, specifically; the proportion of the meshblock who identified as Māori (the indigenous people of NZ) or Pacifika (Pacific Islanders), of individuals who self-report as having been born overseas, and who self-report as having completed tertiary level education; the median household income per meshblock;[69] the change in the median household income between 2001 and 2006, the mean number of household members, and the proportion of the meshblock residents which self-report as not owning their house. These data are summarized in Table 3. In Canterbury, 4,516 meshblocks have at least one valued property with fully recorded claims relating to the 2010–2011 sequence of earthquakes, as well as the corresponding census information.

Table 3: Summary Statistics - Canterbury meshblock level data

	(1)	(2)	(3)	(4)

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[67] On September 4th, 2010, Canterbury was hit by a magnitude 7.1 earthquake. This was followed by a series of aftershocks, the most devastating of which was a 6.3 earthquake on February 22nd, 2011, which took 185 lives.

[68] A meshblock is the smallest unit for which Statistics New Zealand collects data, with boundaries related to population. Censuses are conducted every 5 years. The 2011 census was postponed to 2013 because of the earthquakes.

[69] The top income is censored at $100,000. In 2006, there were 0.03% of meshblocks where the Med HH Income top censored at $100,000, and in 2001 0.01%.

VARIABLES	mean	sd	min	max
Med. HH Income 06	50,835	18,938	5,800	100,000
Dif. in Med HH Income 01-06	10,464	13,579	-61,700	79,200
Prop. Tertiary Educated 06	0.118	0.0906	0	0.556
Prop. Not Homeowners 06	0.295	0.203	0	1
Prop. Maori 06	0.0724	0.0672	0	0.571
Prop. Pasifika 06	0.0214	0.0443	0	0.478
Prop. Born Overseas 06	0.174	0.0967	0	0.800
Mean # HH Members 06	2.558	0.438	1	5

Note: This table contains data on the 4516 meshblocks which are relevant for the Canterbury EQ Series insurance dataset.

As a first step in investigating the distributional implications of the EQC cover, in figure 1, we graphed the payout data by property decile and income decile for all the claims arising out of the Canterbury Earthquake Series dataset. In the figure, we see that as the property decile increases, the average total building payout for the decile increases as well, with a sharpest increase for the tenth decile. This pattern is repeated in the panel on the right where we use median household income deciles.
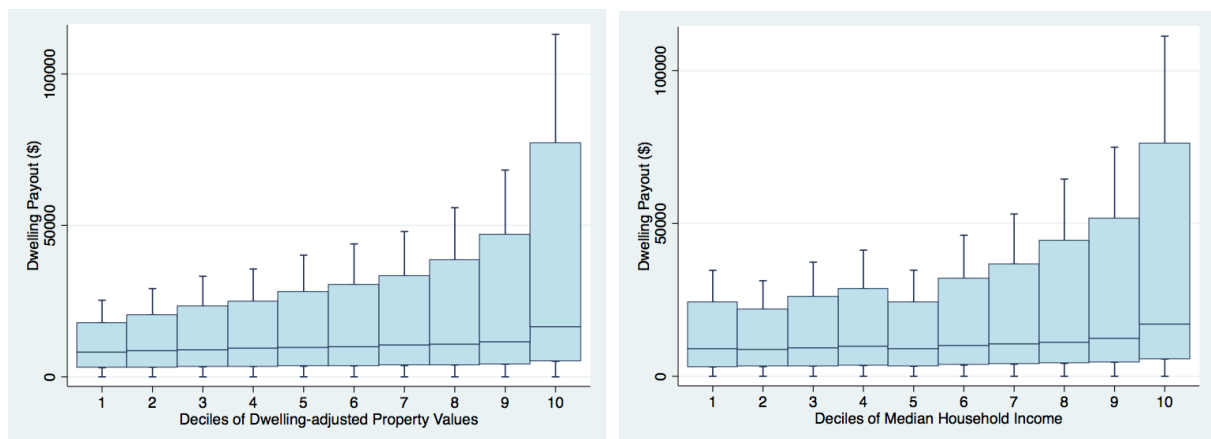

Figure 1: Distribution of Adjusted Building Payouts by Property Value and Income deciles. Canterbury dataset only, excludes zero value payouts. Distribution of payouts per property adjusted by number of dwellings insured by deciles of either dwelling adjusted modelled building value as at mid-2010, or meshblock level median household income as at 2006. Whiskers indicate 0.5 times the IQR, to better show the median values (version with standard whiskers in appendix).

In the boxplots, the middle line indicates the median, the shaded box indicates the interquartile range (IQR), and "whiskers" indicate 0.5 times the IQR. A notable observation is the increase in the spread of the total payout per dwelling as the deciles increase. This reflects higher-value properties require higher cost of repairs. It is worth reminding the reader here that these payouts only take into account the payouts from the public insurer, and significantly damaged homes would very likely have also received repair payouts from their private insurance company.

3. Methodology

Given the identical premiums paid for EQC cover by homeowners, we expected some redistribution to occur. We hypothesized two different mechanisms for the regressivity in this scheme:

1. Wealthier households may live in riskier areas (such as on hillsides or by the water), leading to a higher likelihood of natural hazard exposure, and thus to a higher likelihood of damage.

2. The 100K cap on building payments per event is likely to be more drawn on for wealthier homes since these homes have the capacity to incur more damage. Given the higher value of each component of the home, all else constant, high value homes will incur more damage.

The first mechanism is frequently mentioned as a plausible one for damages from floods, both from storm surges that hit coastal properties and from riverine floods that hit properties on riverbanks. This reason has been suggested as causing significant regressivity in the U.S. and UK flood insurance programs. While admittedly this has not yet been quantified in either of these flood insurance programs, it is less interesting from our perspective. It is less relevant for earthquakes, whose exact location and seismic wave propagation are more random and less oriented with obvious external characteristics determining the spatial distribution of housing. In the case of the Canterbury earthquakes, the 22/2/2011 earthquake's epicentre was located to the southeast of the city; in general the eastern suburbs are less wealthy while the north-western suburbs, further away from the epicentre of the earthquake, have the higher value properties and higher-income households.

The focus of our analysis of the Canterbury experience was hence the second mechanism. The hypothesis we examined was that wealthier homeowners own properties that are likely to be costlier to repair than their less well-off counterparts. For example, a larger house usually has more interior floors that may crack, and these floors may be made from more expensive materials. Naturally, there are also possible mechanisms that can lead to the opposite outcome: perhaps newer or better-maintained houses are less vulnerable to earthquakes as they were built to higher seismic standards.

To identify the effect of the 100K cap, we first looked at whether higher-value homes in Canterbury sustained higher damages from the Canterbury Earthquake Series. In this case, wealthier homeowners were identified either by the value of the home or by the average

socioeconomic status of the residents in the respective meshblock.[70] We regressed the assessed repair cost on the most recent valuation of the property, as well as a number of indicators of the socioeconomic level of residents, as indicated below:

$$Y_i = \alpha + \beta_1 PropertyValue_i + \beta_2 MedHHIncome_i + \gamma X_i + \varepsilon_i$$

where $Y_i = TotalRepair_i$ is the sum of all assessed repair costs made for property *i* for claims related to earthquake events during the specified location (Canterbury) and time period (2010–2011). The error term, ε_i, is clustered at the meshblock level to account for some of our explanatory variables only varying at this aggregate level.[71] In a second specification, which better captures the regressivity of the EQC scheme as it is currently structured, the dependent (LHS) variable is the total payout on a property against the same covariates, including the most recent valuation of the property and a number of control variables at the meshblock level ($Y_i = TotalEQCpayout_i$). We estimated several alternative specifications to test the robustness of our results and to attempt to identify areas of variation that might require further analysis.

4. Results and Discussion

Results are shown in Table 3. In columns 1–3, we used Total Actual Assessed Repair Costs as the dependent variable, and in columns 4–6 we used Adjusted Total Dwelling Payout. Columns 1 and 4 show our comprehensive specifications. The first clear result is that the coefficients of interest (those on property value or median household income) are always positive and statistically significant at the 1% level. Their magnitude is such that for every NZ$ 1,000 of higher dwelling value, we found approximately a NZ$ 62.70 increase in Total Actual Assessed Repair cost, holding other factors constant, including median household income in the meshblock. Further, for every NZ$ 1,000 of higher building value, we found approximately $28.30 more to have been paid out from EQC to the homeowner. The association of higher values in these wealth/income indicators was more than twice as large for assessed repair costs than for the actual EQC payouts.

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[70] Due to the nature of the available data, we could not identify whether a single homeowner owned multiple properties. Given this missing indicator of the particularly wealthy our results are likely to be conservative. Furthermore, although the property valuation spoke somewhat directly to the wealth of the homeowner, the census data related to the residents of these meshblocks rather than the homeowners. Thus, for example, a "slum lord" who owned a number of cheaper properties in low socioeconomic areas could not be identified cleary. However, these are unlikely to be very important considerations as the majority of houses were owner occupied (67% of the 2006 Census stated occupied private dwellings were owner occupied).

[71] We estimate this with heteroscedastic and cluster robust standard errors (Cameron & Miller, 2015). We also performed this analysis at the claim level (rather than summing all claims for a single property). The results were very similar, and are available upon request.

The effects of the meshblock-level explanatory variables were qualitatively the same for both dependent variables, and consistently affected the dependent variables in the expected directions. The growth in median HH income (2001 to 2006) had a negative effect when statistically significant; so that the "newer" the wealth in the area, the lower the assessed damage and EQC payout. It has been suggested in numerous media reports that because of the bureaucratic complexity of the insurance system, more educated claimants find it easier to navigate the system and successfully claim for higher damages. This hypothesis justifies the tertiary education measure we included as an explanatory variable. As hypothesized, the coefficient was positive and statistically significant. It has also been suggested that homeowner that live in the house are more likely to negotiate with the insurer to expedite the process (thus putting renters whose property was damaged at a disadvantage). This variable was statistically significant and negative as hypothesized. Another possible factor was the number of household members. As hypothesized larger household size, another imperfect proxy for socioeconomic status, was also negative and statistically significant.

We also included a number of ethnicity variables at the meshblock level. The Proportion Maori and Proportion Pasifika are included to check if the scheme is having an adverse effect on these minorities, which are of particular importance to New Zealand. In NZ, both ethnicities are identified with lower income, on average, though the Pasifika population (those originating from other Pacific Islands) are generally more disadvantaged, with a significant proportion using English as a second language. However, after controlling for income, education, and family size, which also proxy for socioeconomics, these ethnicities are statistically identified with positive effects on both damages and payouts. Finally, we also included the proportion of the population born overseas, as tabulated in the 2006 census, in case the claim process is more difficult for this group to navigate because of language barriers, fewer local social ties, lack of communication with assessors about deadlines, etc. The assessed repair costs are not significantly affected by this measure. However, there does appear to be a negative effect on total dwelling payouts. Finally, if the property is in a rural meshblock, we see negative effects on both damages and total payouts; likely because most rural meshblocks were further away from the quake's epicentre.

Table 4: Regression Results - Canterbury Earthquake Series

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Assessed Building Repair Costs			Total Dwelling Payout		
Adjusted Building Value 10	0.0627***	0.0730***		0.0293***	0.0347***	
	(0.0159)	(0.0179)		(0.00746)	(0.00854)	
Median Household Income 06	1.292***		1.420***	0.672***		0.732***
	(0.149)		(0.147)	(0.0712)		(0.0703)
Dif. in Med HH Income 01-06	-0.833***	-0.0726	-0.902***	-0.365***	0.0302	-0.397***
	(0.161)	(0.132)	(0.161)	(0.0775)	(0.0654)	(0.0779)
Proportion Tertiary Educated 06	103,574***	197,951***	106,558***	83,202***	132,269***	84,597***
	(20,394)	(19,703)	(20,508)	(10,559)	(10,103)	(10,601)
Proportion Not Homeowners 06	-23,627**	-55,634***	-26,192***	-14,753***	-31,393***	-15,949***
	(9,456)	(9,642)	(9,405)	(4,871)	(4,852)	(4,839)
Mean Number of HH Members 06	-32,614***	-13,092***	-32,146***	-16,195***	-6,045***	-15,975***
	(4,079)	(3,609)	(4,080)	(2,075)	(1,921)	(2,076)
Proportion Maori 06	102,083***	64,382**	92,131***	84,204***	64,603***	79,552***
	(27,197)	(27,240)	(27,021)	(15,263)	(15,260)	(15,206)
Proportion Pasifika 06	109,149***	80,271**	106,030***	78,503***	63,490***	77,048***
	(37,399)	(37,798)	(37,435)	(20,815)	(21,036)	(20,842)
Proportion Born Overseas 06	-20,079	-41,085**	-19,295	-16,179*	-27,099***	-15,816*
	(15,813)	(16,106)	(15,818)	(8,796)	(8,967)	(8,791)
Rural Meshblock	-45,910***	-45,407***	-44,727***	-29,024***	-28,762***	-28,471***
	(2,704)	(2,690)	(2,688)	(1,387)	(1,382)	(1,382)
Constant	60,150***	69,677***	72,702***	37,980***	42,933***	43,839***
	(10,687)	(10,981)	(10,134)	(5,474)	(5,601)	(5,245)
Observations	94,686	94,686	94,687	94,686	94,686	94,687
R-squared	0.041	0.033	0.036	0.080	0.066	0.073

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. This table contains results from OLS regressions with meshblock level clustered standard errors. The dataset includes information on all claims made to the NZ EQC related to insured damages following the sequence of earthquakes in the Canterbury region for events from 2010-2012. The dataset is at the property level and excludes zero value claims (those which did not receive EQC funded repairs). The raw claims data is confidential because of privacy concerns. The other explanatory variables are all gathered from publically available Census tabulation from StatisticsNZ. These are meshblock level variables as collected from the 2006 Census.

In Table 5, the consequences of progressively removing some of the explanatory variables are presented. In column (1) (identical to column (4) in Table 4) we see that all the explanatory variables are statistically significantly different from zero at the 1% level, with the exception of the population born overseas. We first removed the growth in median household income from 2001 to 2006, as this had a more tenuous theoretical effect on payouts; as presented in column (2). This resulted in a decrease in the effect of 2006 Median Household Income, and had a small positive effect on the coefficient for Building Value. In column (3) we removed the least statistically significant variable: the proportion of the meshblock born overseas. The coefficient on median household income increased slightly and became marginally more precise, while the effect of building value remained unchanged. Dropping the proportion of the tertiary in column (4) led to a sharp increase in the effect of median household income, corroborating the widely established observation that education and income are positively correlated, and showing that without controlling for education, we might overestimate the income effect. This also led to a slight increase in the effect of building value, and interestingly, also decreased the absolute values of the coefficients on the ethnicity measures. In column (5) we removed ethnicity and household member controls, bringing building value down marginally, median 2006 household income down sharply, and removing all statistical significance for the proportion not homeowners. Removing this last proportion in column (6) completed our robustness checks, with negligible effects on the coefficients of interest.

Our primary results remained robust throughout these checks. Tertiary education and changes in household income appeared the most closely correlated with median household income. The proportion not homeowners appeared to affect the dependent variable only through our other controls. There was clearly some cultural effect at work as well, since controlling for income and education increased the absolute value of the coefficients on ethnicity controls.

5. An easy solution to the regressivity problem

Fixing the unfortunate regressivity of the NZ natural hazard insurance system is remarkably simple: rather than paying a flat premium per year, homeowners could be required to pay a set percentage of total sum insured. This reflects the facts we observed in this paper, in particular that homes with a larger sum insured are more likely to claim larger amounts, even when there is a flat cap (of NZ$ 100,000) per dwelling. In this case, this modification would prevent the regressivity shortcoming that plagues this scheme and so many other public natural hazard insurance programs as well.

Table 5: Regression specification testing - Canterbury Earthquake Series

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
			Total Dwelling Payout			
Adjusted Building Value 10	0.0293***	0.0306***	0.0306***	0.0319***	0.0301***	0.0300***
	(0.00746)	(0.00774)	(0.00773)	(0.00796)	(0.00741)	(0.00736)
Median Household Income 06	0.672***	0.483***	0.497***	0.719***	0.496***	0.492***
	(0.0712)	(0.0589)	(0.0582)	(0.0556)	(0.0506)	(0.0459)
Dif. in Med HH Income 01-06	-0.365***					
	(0.0775)					
Proportion Tertiary Educated 06	83,202***	92,001***	85,173***			
	(10,559)	(10,540)	(9,737)			
Proportion Not Homeowners 06	-14,753***	-18,481***	-20,978***	-8,664*	823.1	
	(4,871)	(4,892)	(4,590)	(4,441)	(4,338)	
Mean Number of HH Members 06	-16,195***	-14,614***	-15,280***	-17,352***		
	(2,075)	(2,079)	(2,036)	(2,065)		
Proportion Born Overseas 06	-16,179*	-17,403**				
	(8,796)	(8,831)				
Proportion Maori 06	84,204***	80,456***	87,786***	61,651***		
	(15,263)	(15,255)	(14,386)	(14,023)		
Proportion Pasifika 06	78,503***	74,289***	71,366***	52,260**		
	(20,815)	(20,899)	(20,875)	(20,821)		
Rural Meshblock	-29,024***	-28,971***	-28,283***	-31,174***	-34,055***	-34,104***
	(1,387)	(1,391)	(1,365)	(1,341)	(1,321)	(1,240)
Constant	37,980***	39,749***	38,583***	42,245***	13,120***	13,576***
	(5,474)	(5,506)	(5,511)	(5,575)	(3,942)	(2,628)
Observations	94,686	94,686	94,686	94,686	94,686	94,686
R-squared	0.080	0.076	0.076	0.065	0.054	0.054

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

This table contains results from OLS regressions with meshblock level clustered standard errors. The dataset includes information on claims made to the New Zealand Earthquake Commission related to Earthquakes or Fires following the sequence of earthquakes in the Canterbury region of New Zealand for events from 2010-2012. The dataset is at the property level and excludes zero value claims (those which did not receive EQC funded repairs). Raw data confidential. Data source: EQC. *Total dwelling payout* is an aggregate variable including both any cash settlement made to the property and any payout for managed repairs by EQR, divided by the number of dwellings insured on that property. *Adjusted Building Value 10* is the building value for the portfolio, divided by the number of dwellings insured on the property. The other explanatory variables are all gathered from publically available Census data from Statistics New Zealand. These are meshblock level variables as collected in 2006.

6. Conclusions

In almost all cases where homeowners are exposed to a significant risk of sudden-onset natural hazards, the private insurance sector elects not to insure against these hazards.[72] Direct public provision or subsidization of insurance are therefore necessary if such cover is perceived to be socially desirable. Unfortunately, public natural hazard insurance has adverse distributional consequences in almost all cases. This paper's aim is not only to describe the socioeconomic direction in which these insurance-related financial transfers are flowing, but to quantify them. The mechanism for wealth transfer in public earthquake insurance analyzed in this paper facilitates upward transfers—the poor are subsidizing the rich.

Our analysis of the Canterbury Earthquake series, and the functioning of New Zealand's public insurer, offers two insights. First, it clearly supports the hypothesis that more expensive homes receive higher payouts irrespective of their exposure to the hazard; i.e., higher sums that are a direct consequence of the higher value of the affected properties. Secondly, it suggests that capping coverage and having flat premiums, both of which aim to deliver a more equitable scheme, are not sufficient; even these kinds of programs end up transferring risk from homeowners of expensive homes to homeowners of lower-value homes (and in some other cases to non-homeowners). Our finding in the New Zealand case, suggests that many other seemingly more egalitarian natural hazard insurance systems are regressive as well.

With this work, we aim to improve the functionality of public natural hazard insurance, by drawing attention to the distributional function of these schemes. In the New Zealand case, the regressive effect can be counteracted by a simple shift from effectively flat premiums to a set percentage of the total private sum insured (while maintaining the coverage cap). Future research should extend this type of analysis to other public natural hazard insurance schemes in other countries, so that the adverse distributional characteristic of these programs is avoided.

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[72] The many reasons why this is the case are discussed in Kusuma et al. (2017).

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