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The Income Consequences of Managed Retreat

Abstract

Managed retreat - the relocation of households or infrastructure out of harm's way - is one of the most frequently recommended policies to reduce exposure to future losses from disasters. After the 2011 Christchurch earthquake in New Zealand, around 16000 people were relocated from their communities through a managed retreat program (the Residential Red Zone - RRZ). We use comprehensive, individual-level, administrative, panel data from Canterbury (2004-2018), and a difference-in-difference evaluation method to identify the effects of displacement on the RRZ population. We find that compared to their non-relocated neighbors, the RRZ population experienced a significant initial decrease in their wages and salaries, and in their total income. The impacts varied with the time spent in the re-zoned area, and the timing of their move. Wages and salaries of those who were red-zoned and moved in 2011 were reduced by 9%, and 10.4% for those who moved later (in 2012). Women faced greater decreases in wages and salaries, and total income. There were no discernible impacts of the relocation on self-employment income. In sum, we find strong evidence that the managed retreat program had identifiable adverse real effects on personal income. This finding has direct implications for the compensation packages that should be allocated in future managed retreat programs.

JEL-Codes: Q540.

Keywords: climate change adaptation, managed retreat, income.

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IDI disclaimer: The results in this paper are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) managed by Statistics New Zealand. Access to the anonymised data used in this study was provided by Statistics New Zealand in accordance with security and confidentiality provisions of the Statistics Act 1975. The findings are not Official Statistics. The results are based on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes and is not related to the data's ability to support Inland Revenue's core operational requirements. The opinions, findings, recommendations, and conclusions expressed in this paper are those of the author(s), and not Statistics NZ.

1. Introduction

Managed retreat - the relocation of households or infrastructures out of harm's way - is considered as one of the most appropriate responses for some locations to reduce exposure to future risk from disasters (Alexander et al., 2012, Thaler et al., 2016). Under the best of circumstances, relocation may bring many benefits to at-risk communities. Of the most common adaptation strategies, early managed retreat is usually the surest way to protect people and property from disaster risks (Bragg, 2021). It is likely to be less costly than protection strategies that involve maintenance of hard infrastructure or eventual dismantling of eroded property (Albel et al., 2011; Alexander et al., 2012; Koslov,2016). In many cases, it may be the most effective and sustainable strategy to reduce exposure to harm, with the added potential for long-term environmental and socio-economic co-benefits (Hanna et al.,2021).

While managed retreat has a compelling logic to it, it is typically heavily constrained by the strong emphasis in many legal systems on private property rights (Hartmann 2011). Therefore, in practice, managed retreat often faces many political and economic challenges. It has, after all, the potential to disrupt communities, and cause health, socio-cultural, and economic adverse impacts to those that relocate (Dannenberg et al.,2019). It may thus inadvertently and unintentionally increase, rather than decrease, vulnerability (Hanna et al., 2017). Managed retreat decisions mostly involve three groups: the affected community (both homeowners and renters), the local authorities, and the central government (Noy, 2020). As such, to implement an effective managed retreat program, policy makers need to understand these participants' concerns, incentives, and interests when setting the how, where, and when of the planned retreat.

Historically, we observe several successful managed retreat programs that we can learn from. One example where retreat was considered a success is the case of Valmeyer, Illinois (Koslov, 2016). Two-thirds of the town's nine hundred residents were relocated two miles to the east to higher ground, following the 1993 Great Midwest Flood. Residents chose to relocate but keep the town together and planned the move collectively. The town was rebuilt with financial support from the Federal Emergency Management Agency (FEMA). In contrast, planned retreat from Byron Bay, Australia which was first announced in 1988 had a very different result. Planning controls were implemented by Byron Shire Council in New South Wales (NSW), requiring both existing and proposed development to be relocated when 20-50 meters from an erosion escarpment. However, this policy has since been abandoned due to immense political pressure and legal actions pursued by homeowners as a result of a perceived

inconsistent application of the mandates, and their implications for property values (Harker, 2016). Affected residents have claimed that no social, economic, or environmental advantages from a retreat policy have been demonstrated, and therefore resisted the program (Buckley, 2008).

Given the challenges that at-risk communities and their governing authorities face, learning policy lessons from previous managed retreat programs is crucial. This knowledge can help planners design better relocation programs and avoid some of the well-intentioned and unintended failures that often beset such efforts (Hoang and Noy, 2020). While there is a rich literature on relocation and resettlement in the context of economic development, there is a lack of empirical evidence on communities relocated in the context of disasters or environmental risks (McAdam and Ferris, 2015; Petz, 2015).

In New Zealand, a large managed-retreat program was implemented in Christchurch, after the 2011 earthquake the city experienced. In June 2011, the government decided to red zone some of the worst affected areas. In those areas, most buildings were found to be uneconomic to repair or too risky to inhabit, and the success of engineering solutions was deemed to be uncertain and/or too costly. There was significant and extensive area-wide land damage, largely caused by liquefaction and slope instability, and a high risk of further damage to land and buildings from even low levels of shaking. Homeowners were told that these areas would no longer be zoned for residential use, and they were required to move away. The government compensated them by offering to purchase their house and land. This decision ultimately affected 8,060 properties and more than 16,000 people across Greater Christchurch (MacDonald et.al., (2016). As such, this was an exceptionally large managed-retreat program internationally (Hino et al., 2017).

The Red Zones eventually encompassed land near the Waimakariri River, parts of the land in Christchurch City along the Avon River, and parts of the Port Hills. The areas near Waimakariri and the Avon were announced in 2011 while a small western part of the flat land and the Port Hills areas were red-zoned in 2012 and 2013 (Figure 1). In declaring these Red Zones, the government's purpose was to lead residents in these zones to relocate away from these risks and enable them to get on with their lives as quickly as possible by providing them compensation for their homes and land.[1] By April 2015, approximately 7,800 property owners

[1] Some red zone property owners were not happy with these compensation offers and felt that they had no choice but to accept them (Mitchell, 2015). There were also media reports that some residents were included "reluctantly and under duress", despite the official court proceedings showing the contrary (Smith, 2021).

(over 95 percent of the eligible group) had accepted the government's offer to sell their properties to the Crown, most had already settled, and nearly all had already relocated.

The questions of what happened to Red Zone residents' wellbeing after retreat are less understood. Nguyen (2020) examined the factors that drove homeowners' choices between the two kinds of compensation offers they were given. Hoang and Noy (2020) analyzed a survey that focused on the residents' subjective wellbeing (quality of life, stress level, and emotional wellbeing). However, these studies used data available only on the Red Zone residents, so they could not conclude anything about the impact of being 'Red Zoned' had in shaping those residents' outcomes.

A mandated relocation may be associated with adverse economic outcomes for those who are forced to relocate. As can be expected, research that has looked at forced relocations because of the destruction wrought by disasters in low- and middle-income countries has found adverse impacts on income and employment, but these relocations are rarely managed well, nor are they adequately compensated, if at all (e.g., Godamunne, 2012; Badri et al., 2006). However, the connections between managed retreat programs, where people are given long advance notice for the need to move, and economic outcomes have yet to be examined empirically (Noy,2020).

Here, we shed some light on the impacts of managed retreat programs on the affected population by examining the Red Zone residents' income before and after their relocations, and by comparing them to other Christchurch residents who experienced similar levels of property damage from the earthquake but lived outside of the Red Zone. The paper also exploits the variation in the timing of RRZ residents moving to evaluate how relocation followed by a managed retreat changed individuals' income. We do this by using Statistics NZ's Integrated Data Infrastructure (IDI), which includes administrative unit-record data on all people living in New Zealand. We use income data, decomposed by its sources (wages and salaries and self-employment income), that is available from the New Zealand tax authority.

We apply a difference-in-difference (DiD) technique that separates the 'treated' (those who moved because of their location within the RRZ) from the 'control' (those who never reside within the RRZ). Our methodology also allows us to analyze how the implementation of managed retreat program affected income over time - up to 7 years post-relocation. The objectives of this research are thus: (1) to estimate the impact of mandatory relocation (managed retreat) on the income of displaced individuals over time; (2) to evaluate whether the impact of relocation varies by the timing of the move and demographic factors (gender, age,

and ethnicity); and (3) to relate these findings to possible policy lessons for the design of future managed retreat programs.

We find that relocated Red Zone residents experienced an income decline, both for their 'wages and salaries' component, and for total income from all sources. This adverse impact is more severe for women and for individuals who were red-zoned later. More specifically, wages and salaries of women who were red-zoned and moved in 2011 declined by 12%, and by 19.6% if they were red-zoned and moved later (in 2012). Overall, income decreased right after they moved, and it took about 2 years to observe a nascent recovery signal (even though, on average, they did not get back to the income of the control group by 2018 – the last year we examined) (Figure 5-6). Furthermore, the effects on the youngest age group (20-29 years old in 2011) were largest, so that people at their early career stage faced greater decreases in wages and salaries, than older cohorts. We find no discernible effect of the relocation on people's self-employment income, for both men and women.

The next section provides an overview of the Residential Red Zone (RRZ) program; while section 3 describes the data we use here. Section 4 details the empirical specifications we estimate, and the results of this statistical analysis are described in section 5. Some robustness checks are provided in section 6, and section 7 concludes with some further observations.

2. Residential Red Zone (RRZ) program

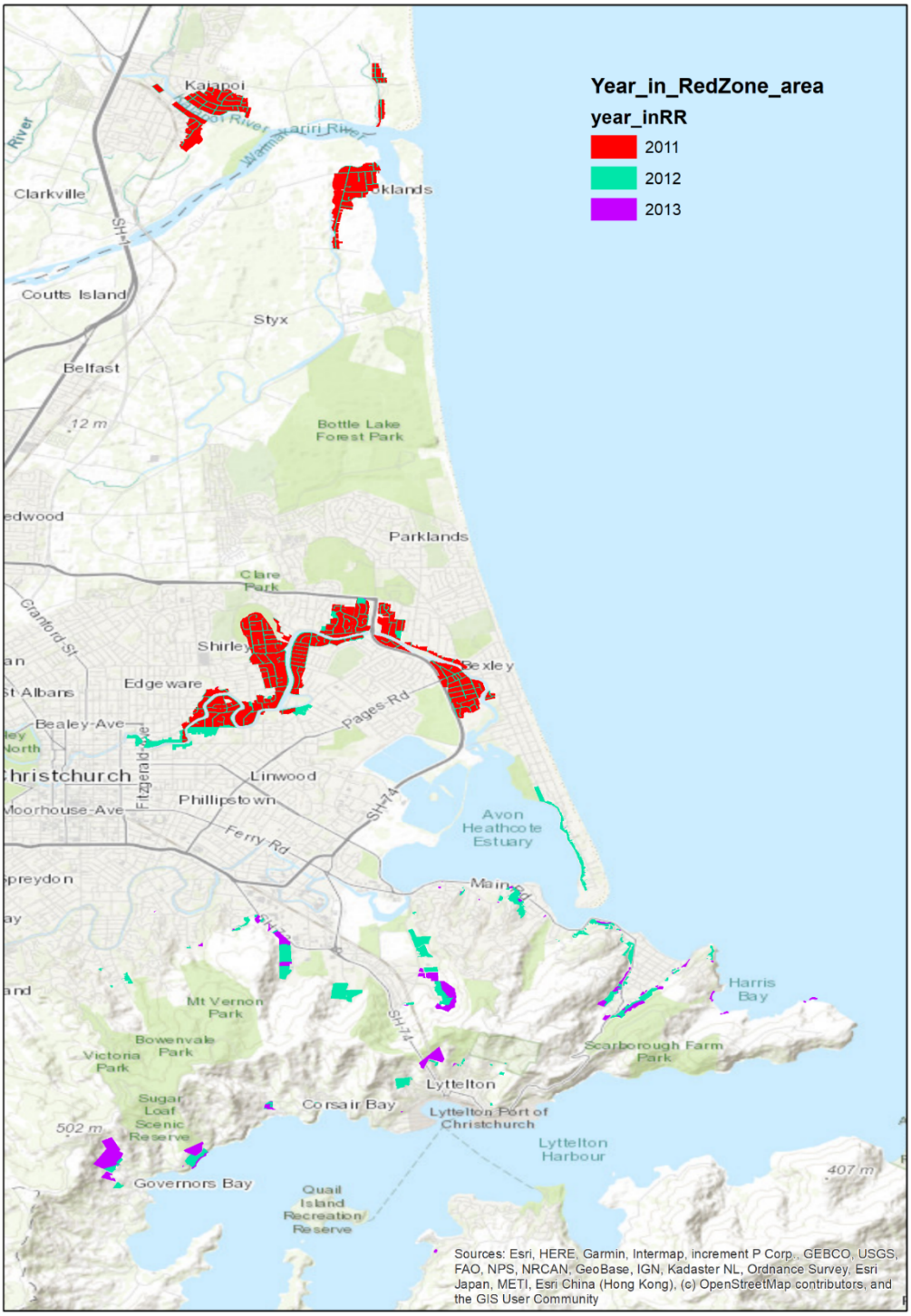
After the devastating earthquake on the 22nd of February 2011, the government re-zoned several areas in Christchurch. In the initial announcement about the re-zoning, on the 23rd of June 2011, the earthquake-affected areas were categorized into four zones: red zones which were mostly liquefaction-prone areas along the Avon river in Christchurch and the Waimakariri river north of the city; orange zones which were determined to require further investigation, green zones which were areas deemed viable for repair or reconstruction of damaged property, and white zones which still needed to be mapped or were already classified as non-residential land. Most of the white zone properties were in the Port Hills and the central business district areas. From that time to the end of 2011, several further adjustments re-zoned white and orange zone land to green. In February and March 2012, around 450 properties across Greater Christchurch were re-zoned from orange to red. From May till the end of 2012,

properties in the Port Hills (around 650 properties) and South Shore West (around 200 properties) were rezoned from white to red as well.[2]

On the 24th of August 2012, the completion of the flat-land zoning review was released, followed by that of the land-zoning process for Greater Christchurch on the 31st of October 2012. The final review process of the re-zoning program decisions was completed by the end of 2013. As of March 2016, a total of 8060 properties across Greater Christchurch had been zoned red. Figure 1 maps the Red Zone area locations and the time they were categorized as RRZ (a timeline is provided in Appendix 2).

[2] This brought the total number of the Red Zoned Port Hills properties to 714. The Port Hills red zones were identified later than the flat lands, largely because of the technical complexity in assessing risk (from rockfalls rather than from liquefaction, as in the flat lands).

Fig 1: The Canterbury Red zones



Source: The authors

3. Data

This study used linked data from Statistics New Zealand Integrated Data Infrastructure (IDI), which is a wide collection of government administrative and survey data that is linked together at the individual level and aims to include everyone living in the country.

The IDI contains information about the address updates that individuals have provided to various government agencies, and addresses recorded in surveys (such as the census). For privacy reasons, data in the IDI is only accessible in restricted StatisticNZ data labs. Exact addresses are not available for researchers, but the individuals are linked to a meshblock. A meshblock is a defined geographic area, varying in size from part of a city block to large areas of rural land. It is the smallest geographical area in NZ standard geographic classification, representing roughly 30 to 60 dwellings (about a hundred people).[3]

Our first task is to identify people who lived in the Residential Red Zone (RRZ) areas at the time the zoning announcements were released. To do this, we first defined the RRZ meshblocks by overlapping the RR map and the geographical map (in 2018) provided by Statistics NZ. In total, there are 348 distinct red zone meshblocks, in which 87 are boundary meshblocks which overlap both RRZ and non-RRZ areas. Most of the boundary meshblocks are in the Port Hill areas (16 in Sumner, 10 in Lyttelton, 7 in Moncks Bay). As a meshblock is the smallest geographic unit in the IDI data, we cannot identify the location of properties more precisely. We therefore removed the residents in the boundary meshblocks from our sample (as these meshblocks are partly in the RRZ, and partly outside it). Table 1 illustrates the number and percentages of RRZ meshblocks. Only 6 out of 261 non-boundary meshblocks were red-zoned in 2013.

Table 1. Numbers of Red Zone Meshblocks

Year in RRZ areas	Boundary	Non-boundary	Total
2011	15	180	195
2012	57	75	132
2013	15	6	21
Total	87	261	348

[3] As areas grow and change, meshblocks get updated and can be compared overtime by the meshblock concordance table in the IDI. Meshblocks are combined to create larger aggregations - area units, territorial authorities, and regions. Territorial authorities are the second tier of local government in New Zealand, below regional councils and are defined under the Local Government Act 2002 as city councils or district councils. In 2018, there were 67 territorial authorities: 12 cities, 53 district councils, Auckland Council, and Chatham Islands Council.

After labelling the list of red zone meshblocks, we joined it to the full address dataset to identify the red zone residents whose RRZ address notification date were from 1st February 2010 to 23rd June 2011; and their record of moving (time and destination).

This study cohort consists of RRZ residents and those who were living elsewhere in the same territorial authorities (Christchurch and Waimakariri districts) at the time that the managed retreat program was announced. We narrowed the group of 'control' people (against whom we compare the RRZ residents) to those who were living in meshblocks that were affected by the same earthquake intensity shake levels in February 2011, ranging from 6.2 to 8.6 (these are identified through a shake map produced by the USGS). By doing this, we assumed that the properties belonging to people in the treatment and control group were similarly affected by the 2011 earthquake.[4]

We interpret the large managed retreat program as a quasi-random shock to mobility. We can estimate the causal effect of the forced move by comparing outcomes (total income, wages, and salaries - representing the employment effect, and self-employment income) for those whose houses were in the RRZ and had to move (our treatment group) versus those whose houses were out of red zone areas but were still in the same larger geographical area and experienced similar earthquake intensity (our control group).

We merged the list of people (treatment and control) with their tax records, their education, and personal demographic information (age, gender, ethnicity) available from the census. Therefore, we were able to study the economic consequences of the mobility shock over the next 7 years, for the individuals affected. We further restricted the sample to those aged 20-60 at the time of RRZ program announcement (in 2011), to capture only the working-age population. We used data from 15 years (2004-2018). People without total income (income from all sources) in 2011 (equal to 0 or missing) were also removed from the sample.

77.3% of the former RRZ residents were still in this area in 2011, 22.4% were in the RRZ in 2012, and only 0.3% were still categorized in the RRZ in 2013. Among them, 82% relocated within the Canterbury region. Moreover, 66% relocated within the same territorial authority (Christchurch City or Waimakariri district) – see Tables 2 and 3. For those people whose properties were red-zoned in 2011, the top three destination regions for those who moved away were Auckland, Otago, and Wellington (table 4)

[4] We note that the RRZ classification was based on the assessment of future risk in these locations, and not on the damage experienced during the earthquake (indeed, in some locations houses that suffered no damage in the earthquake were classified within the RRZ).

Table 2. Number of People in RRZ Over Time

Year in RRZ areas	Number of people	Percentages (%)
2011	4302	77.3
2012	1245	22.4
2013	18	0.3
Total	5565	100

Table 3. Destinations of Relocated RRZ Residents

Destinations	Number of people	Percentages (%)
Regions		
In the Canterbury region	4572	82.2
Out of the Canterbury region	993	17.8
Territorial authorities (TA)		
Same territorial authorities	3684	66.2
Different TA, still in the Canterbury region	891	16.0
Different TA, outside the Canterbury region	993	17.8

Table 4. Destination and Move Date of RRZ Residents

Moved year	Destination (region)	Percentages (%)
2011	Stayed in Canterbury	82.16
	Auckland	4.4
	Otago	2.7
	Wellington	1.9
	Marlborough	1.5
	Bay of plenty	1.3
	Tasman	1.1
	Westcoast	1
	Others	4
2012	Stayed in Canterbury	89.56
	Auckland	2.4
	Otago	1.7
	Wellington	1
	Others	5.3
After 2013	Stayed in Canterbury	89.36
	Auckland	2
	Otago	3
	Wellington	1
	Others	4.6

Table 5. Descriptive Statistics

Variables	Control group			Red zone group			Balance tests
	N	*Mean or %*	*SD*	*N*	*Mean or %*	SD	
Gender	157206			5565			$\chi2$=1.884
Male	79389	50.5%		2755	49.5%		
Female	77817	49.5%		2810	50.5%		
Tertiary education enrolment	157206			5565			$\chi2$=1.321
No	40023	25.5 %		1455	26%		
Yes	117183	74.5 %		4107	74%		
Qualification level	157206			5565			$\chi2$=89.01***
01	4245	2.70%		162	2.90%		
02	14307	9.10%		558	10%		
03	21852	13.90%		852	15.30%		
04	13362	8.50%		495	8.90%		
05	8646	5.50%		351	6.30%		
06	6444	4.10%		234	4.20%		
07	25626	16.30%		729	13.10%		
08	5187	3.30%		117	2.10%		
09	2043	1.30%		45	0.80%		
10	786	0.50%		12	0.20%		
Missing	14307	9.10%		546	9.80%		
No qualification	40088	25.50%		1446	26.00%		
Ethnicity	157206			5565			$\chi2$=15.958***
Non- Māori	140247	89%		4869	87.5%		
Māori	16959	11%		693	12.5%		
Age (in 2011)	157206	37.3	11.82	5565	38.1	11.581	F=26.799***
Total income($NZD)	157206	37781.3	33575.8	5565	36808.1	27406.9	F=4.567**
Wages & salaries ($NZD)	133353	37261.6	33081.4	4713	37041.7	27002.3	F=0.204

Statistical significance markers: * p<0.1; ** p<0.05; *** p<0.01. People aged 20-60 years in 2011. SD refers to the standard deviation; N refers to the number of people.

Residents obviously did not self-select to be hit by the earthquake and/or be red-zoned. In New Zealand, the Ministry for Business, Innovation and Employment divides the country into three risk zones (high, medium, and low).[5] Before the 2010-2012 sequence of earthquakes, Christchurch was classified as low risk. The earthquake was thus not widely anticipated, and neither were the associated hazards (such as landslides and liquefaction). Because of this seismic activity in 2010-2012, Canterbury (including Christchurch) was re-classified as high-risk. We used balance tests to test the similarity of observable pre-treatment features of the people in RRZ areas and their neighbours elsewhere in the city. Table 5 presents the summary statistics of control and treatment group in our analysis, and the balance tests (the last column) for various pre-relocation characteristics that are available in our data. For balance tests, the

[5] These classifications are used in determining required building codes.

Fisher test (F test) was used for continuous variables (e.g., age, wages & salaries, total income), and chi-square tests were applied for categorical variables.

The average age of RRZ residents and control group is similar - 38 years old. In the RRZ group, 49.5% were males, 12.5% were Māori, and 74% enrolled in tertiary education. The control group, similarly, consists of 50.5% males, 11% Māori, and 75% had tertiary education qualification. When we test for differences in these characteristics, we find that there are no systematic differences in gender, tertiary education enrolment, wages and salaries in 2011. In terms of age, qualification level, and ethnicity, the differences are statistically significant but are small.

4. Identification strategy

We aim to estimate the causal effect of managed retreat program on economic outcomes. These are wages and salaries, total income, and self-employment income, by difference in difference method (DiD).

The basic econometric model is:

$$Y_{it}^{*} = \alpha + \beta Treat_i + \boldsymbol{\gamma} Post_t + \delta Treat_i * Post_t + \theta X_{\boldsymbol{it}} + \delta_i + \mu_t + \tau_{TA} + \varepsilon_{it} \quad (1)$$

where Y_{it}^{*} is the disposable income (logarithm or sum of income) for person *i* in period *t*; $Treat_i$ is a dichotomous indicator of treatment (in the RRZ before the managed retreat), $Post_t$ takes a value of 1 for all time periods after the treatment. $\delta_i, \mu_t, \tau_{TA}$ are individual, time, and location fixed effects. *X* is a vector of control variables: Age, age square, gender, ethnicity, highest education level, tertiary education enrolment (binary), job sector. These exogenous control variables can impact income but are not influenced by the treatment. The error term is ε_{it}. We include year fixed effect and Territorial Authorities fixed-effects in all regressions.

Residents were red zoned in different time, and also moved in different time from 2011 to 2016. We investigated the effect of being classified as RRZ residents, and the timing of the exit move on the three dependent income: wages & salaries, self-employment income, and total income (income from all sources). We used tax records, which provide an objective measure of a person's income over time. Income come from several sources; these include wages and salaries, benefit payments from the Ministry of Social Development, Accident Compensation Corporation disability insurance payments, and pension (social security) payments. The list of all income source categories and self-employment income source groups can be found in Appendix 2. We estimate specifications for both the absolute value of income and log of income.

The controls we include are age, age square, ethnicity, highest education level, gender, tertiary education entrance status, job sector, year fixed-effect and location fixed-effect. Ethnicity and gender were taken from the personal details table in the IDI. The table collates ethnicities that are reported in various datasets in IDI. The highest education level and tertiary education entrance data comes from the education quality dataset and tertiary education entrance dataset. The job sector was taken from the tax record table and is coded based on Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC). By adding the vector of control variables, we increase the precision of the treatment estimates, and ideally eliminate any confounding variables to correctly specify the models. With these, we can also investigate possible heterogeneity of the treatment effects.

We estimate equation (1) for the whole cohort, then for men and women separately and by age category (20-29, 30-39, 40-49, 50-60). To capture the full dynamic changes in income, we evaluate the effect for each year following the implementation of the mandated relocation program.

The evidence from balance tests (table 5) states that Red Zone communities and their neighbours were relatively homogeneous. Furthermore, figure 2-3 illustrate the parallel trend in wages and salaries, total income of treatment and control group before the managed retreat program was applied in 2011.

Figure 2. Average 'Wages and Salaries'

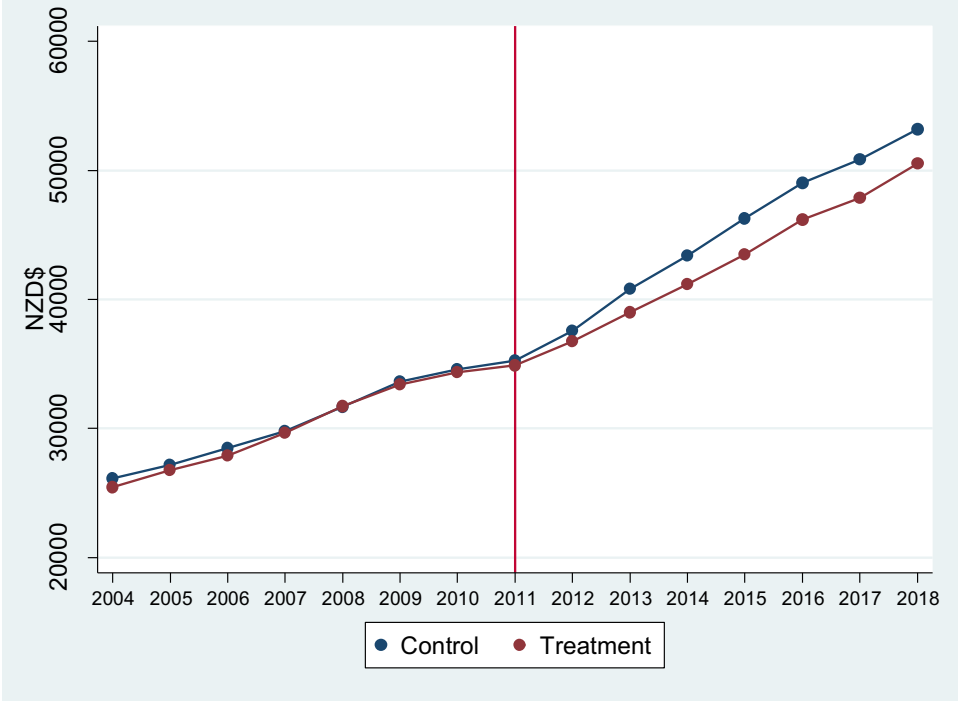
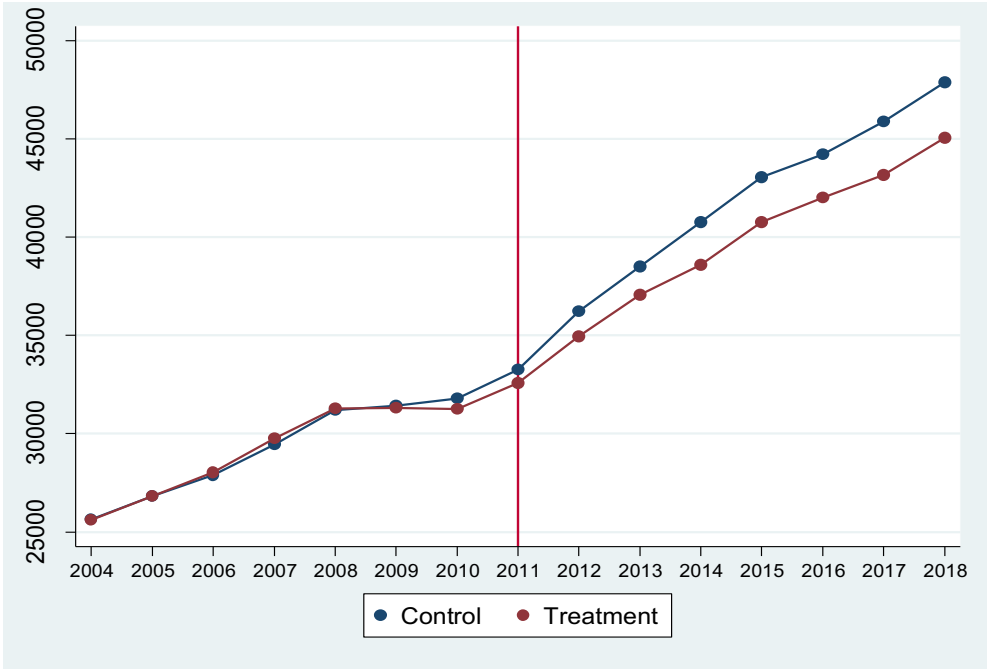


Figure 3. Average Total Income



5. Results

Table 6-9 present the results for the regressions investigating the impact of relocation on income by source. To see how the assignment to be relocated affects income by gender, we estimate the effects separately for men and women. Each result is a separate regression that includes other control variables, including age, age square, job sector, year fixed effect, and

territorial authority fixed-effects. Data shows that the variation in the job sector changing in the panel over 14 years is very small (this variable is dropped out from regressions). We run regressions (use panel robust SEs) for both sum of income and the natural logarithm of each income as the dependent variable. The reported coefficients are the impact of managed relocation. Although an increasing trend in income can be seen in both groups (figure 2-3), our comparisons of average changes show that relocation negatively affected RRZ residents' incomes.

5.1. Wages and salaries

Table 6. Effects by Timing of Red Zoning (LHS: wages & salaries)

Time of being RRZ residents	**All cohort**		**Male**		**Female**	
	Sum	Log	Sum	Log	Sum	Log
	(1)	(2)	(3)	(4)	(5)	(6)
2011	-1829.5****	-0.0658****	-1711.8***	-0.0545***	-1736.5****	-0.0732****
	(-5.38)	(-4.46)	(-3.14)	(-2.77)	(-4.42)	(-3.38)
2012	-2124.8***	-0.104****	-1536.3	-0.0350	-2891.8***	-0.174****
	(-3.04)	(-3.54)	(-1.52)	(-0.94)	(-3.20)	(-3.87)

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses.

Table 6 shows that there is a large and statistically significant reduction in wages and salaries caused by the relocation. Averaging the effects suggests an aggregate decline of 6.6% for people who were Red Zoned in 2011, and 10.4% for people who were in a year later in 2012. For women who were in the Red Zone earlier, their wages and salaries were reduced by 7% while this figure was 17.4% for people who were in Red Zone later. For men, table 6 reveals an aggregate decline of 5.5% for those who were in Red Zone in 2011, but no statistically discernible effect for those there in 2012.

We further break the sample down into sub-groups based on the time they moved out (Table 7). The effect of displacement on wages and salaries for those who were red-zoned in 2011 and moved immediately was large and statistically significant. Compared to their neighbours, their wages and salaries decreased by around 2700 NZ$ (per year) or 10% in a specification with controls (column (2)). The amount of mean lost income from wages and salaries for women were 2760 NZ$ or 12% while these figures were 2140NZ$ or 7% for men. This difference is consistent with a labour force participation rate report that found a steeper decline in the labour participation rate among women in the aftermath of the earthquakes. For those who were red-

zoned in the same year (in 2011) but moved one year later (in 2012), their wages and salaries also decreased (around 1890NZ$ or 5.2%). In this subgroup, as well, women were more negatively affected (2230NZ$ or 6.2%).

For individuals who were red zoned later in 2012, and moved in the same year, their earnings loss was similar overall (10%). The women in this sub-group faced even more negative effects from the RRZ relocation - their earning went down by nearly 2970 NZ$ or 19.6%.[6]

Table 7. Effects by Timing of Red Zoning and Time of Moving (LHS: wages & salaries)

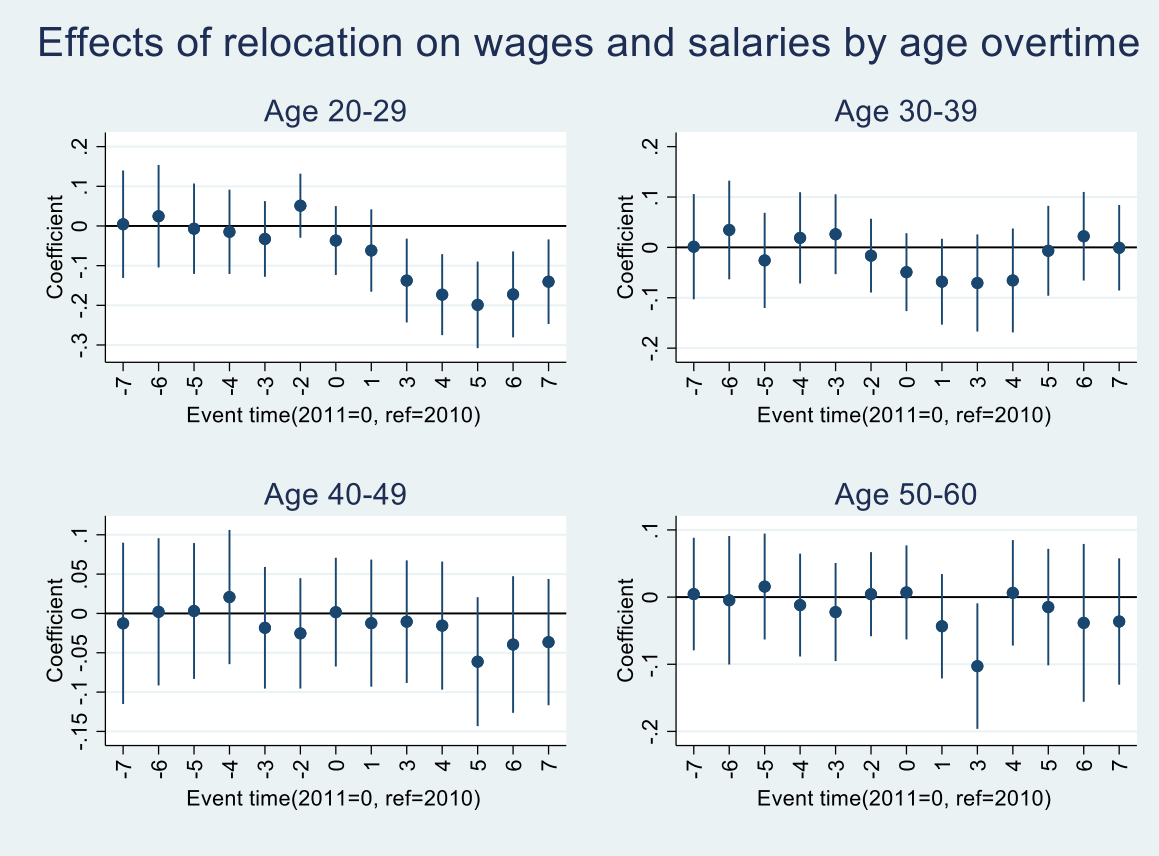
	All cohort		**Male**		**Female**	
	Sum	Log	Sum	Log	Sum	Log
	(1)	(2)	(3)	(4)	(5)	(6)
Being RRZ residents in 2011 & moved in						
2011	-2707.6****	-0.0990****	-2142.5***	-0.0696**	-2756.6****	-0.121****
	(-5.46)	(-4.35)	(-2.66)	(-2.28)	(-4.86)	(-3.67)
2012	-1893.3***	-0.0515**	-1466.9	-0.0386	-2234.3****	-0.0619*
	(-3.18)	(-2.13)	(-1.53)	(-1.22)	(-3.36)	(-1.72)
Being RRZ residents in 2012 & moved in						
2012	-2218.0**	-0.104***	-1410.2	-0.00824	-2968.6***	-0.196****
	(-2.55)	(-2.83)	(-1.10)	(-0.17)	(-2.68)	(-3.53)
2013	-611.8	-0.0517	1641.3	-0.0427	-4335.7	-0.0777
	(-0.29)	(-0.66)	(0.59)	(-0.50)	(-1.64)	(-0.57)

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses.

We also disaggregate our main results by age (in 2011). Figure 4 reports these regressions for four age groups (20-29, 30-39, 40-49, 50-60). The youngest group (20-29) experienced with relocation a decline in their wages and salaries. This effect is strong, statistically significant, and is persistent (7 years after their relocation). It took them 4 years (up to 2015) to start recovering their income. Although there may be some impact on relocated people aged groups from 30-60, it appears that relocation had a much shorter effect on their wages and salaries than on the younger cohort. A full table of regression coefficients for each age group in each year following the relocation is provided in Appendix 3 (table A3.1)

[6] There are no statistically observable impacts of the relocation for people who moved in 2013 or later, but this is a very small group, relative to those who moved in 2011 and 2012 (see tables 1-2).

Figure 4. Effects of Relocation on Wages and Salaries by Age



5.2. Total income

Total income is a sum of income from 15 different sources listed in Appendix 1. Table 8 suggests a large and significant decline in total income following the relocation for all cohorts and for both men and women, regardless of the timing. Column (2) shows a decline by 5.6% for those who were in the RRZ in 2011, and 8.8% for those who were in the RRZ in 2012. The declines for men and women were similar for those who were in the RRZ earlier, but for those in the RRZ later, women experience a larger decrease in their total income (around NZ$2690 or 11.3% compared to around NZD$2000 or 6.2%) (column 3-6)

Table 8. Effects by the Time of Red Zoning (LHS: total income)

Time of being RRZ residents	**All cohort**		**Male**		**Female**	
	Sum	Log	Sum	Log	Sum	Log
	(1)	(2)	(3)	(4)	(5)	(6)
2011	-1546.6****	-0.0559****	-1424.5***	-0.0539****	-1403.7****	-0.0532***
	(-4.74)	(-4.80)	(-2.66)	(-3.40)	(-3.87)	(-3.18)
2012	-2303.7****	-0.0875****	-1999.7**	-0.0618**	-2694.7****	-0.113****
	(-3.64)	(-4.01)	(-2.10)	(-2.25)	(-3.43)	(-3.33)

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Table 9 illustrates results when we divide our treatment group into sub-groups based on the timing of moving. The total income for those who were red-zoned and moved immediately in 2011, their income was reduced by 2546 NZ$ or 8.7% (column 1-2). Interestingly, the amount of mean declines in total income for men (2444 NZ$ or 8.7% (column 5-6)) is slightly larger than for women (2128 NZ$ or 8.1% (column 3-4)). For those who were red-zoned and moved in 2012, their income decreased by nearly 3000 NZ$ or 11%. In this sub-group, compared to the control group (that was not relocated), the income of relocated people was reduced by nearly 3330 NZ$ or 15.8% for women, and 2484 NZ$ or 5.6% for men.

Altogether, there is evidence of a decrease in both wages and salaries and total income for Red Zone residents after they were forced to move. The wages and salaries had a greater decrease than total income, indicating that residents may have received benefits or supports to compensate for their loss or found a varied alternative source of income.

Table 9. Effects by the time of Red Zoning and Moving (LHS: total income)

	All cohort		**Male**		**Female**	
	Sum	Log	Sum	Log	Sum	Log
	(1)	(2)	(3)	(4)	(5)	(6)
Being RRZ residents in 2011 & moved						
In 2011	-2546.1****	-0.0872****	-2443.9***	-0.0874****	-2128.3****	-0.0810****
	(-5.61)	(-5.15)	(-3.22)	(-3.68)	(-4.23)	(-3.41)
In 2012	-1149.3**	-0.0261	-659.3	-0.0156	-1456.4**	-0.0330
	(-1.96)	(-1.35)	(-0.68)	(-0.61)	(-2.36)	(-1.15)
Being RRZ residents in 2012 & moved						
In 2012	-2955.7****	-0.109****	-2483.6**	-0.0558*	-3326.6****	-0.158****
	(-3.82)	(-4.11)	(-2.12)	(-1.65)	(-3.47)	(-3.89)
In 2013	708.0	-0.0558	1721.5	-0.117	-1272.8	-0.00377
	(0.37)	(-0.83)	(0.62)	(-1.39)	(-0.55)	(-0.04)

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses.

We also examined the relocation's impacts on self-employment income, but did not find much statistically significant impact. There is a statistically significant decrease in the sum of self-employment income (column 1), but it is only weakly significant (at 10% level). See Table A7.1 in Appendix 7.

5.3. Dynamics of impacts

In our previous analyses (using equation (1)), we were constrained to a single average treatment effect for the entire span of the post treatment period. Yet, we can also analyse the dynamic effect of relocation on income. Suppose treatment occurs at time k, we estimate the linear panel model with dynamic policy effects:

$$Y_{it}^{*} = \alpha + \sum_{m=-a}^{p} \beta_m \boldsymbol{treat_{it}} + \theta X_{it} + \delta_i + \mu_t + \tau_{TA} + \varepsilon_{it} \qquad (2)$$

where: $t=k+m$. Most of the terms in the equation (2) are the same as in the equation (1): individual, time, and location fixed effects, control variables, and the error term. The key feature of this model is the summation term. It includes *a* leads and *p* lags of the treatment. The income at time *t* can only be directly affected by the value of the policy at most $m \geq 0$ periods. Therefore, any estimates for β for $m<0$ that are statistically different from zero would suggest the model is mis-specified (as the relocation already had an impact on the affected individuals before the earthquakes occurred).

Beyond a placebo-type test, this allows us to measure the relocation effects by year. In Figure 5, we provide graphs displaying the point estimate and 95% confidence interval for the treatment effect over time (7 years pre- and post- the managed retreat event). Full tables (Table A4.1) reporting coefficients for the whole sample, and for men and women separately, are provided in Appendix 4.

Figure 5: Dynamic Effect of Red Zoning on Wages & Salaries (RRZ areas in 2011)

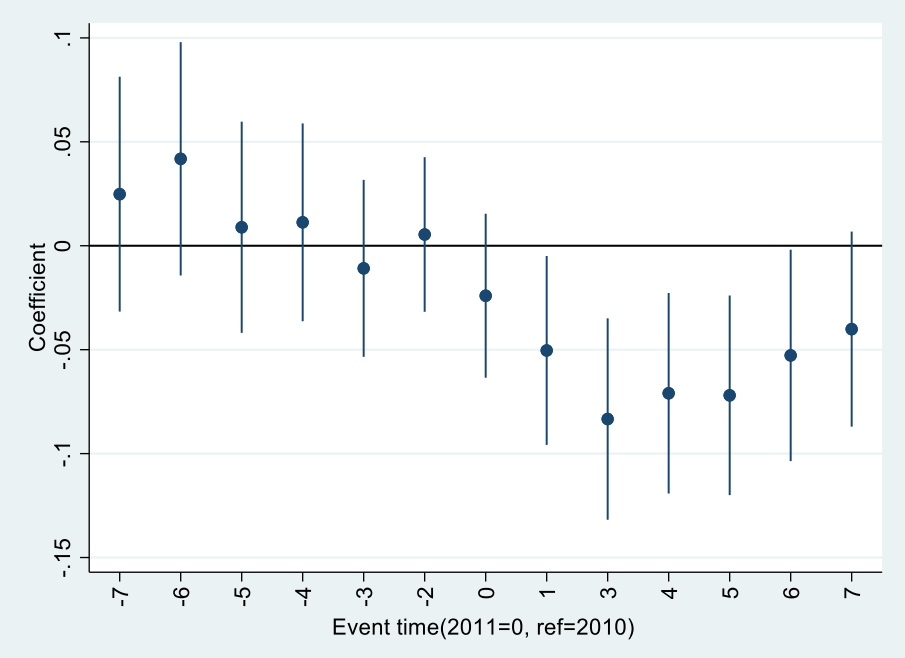
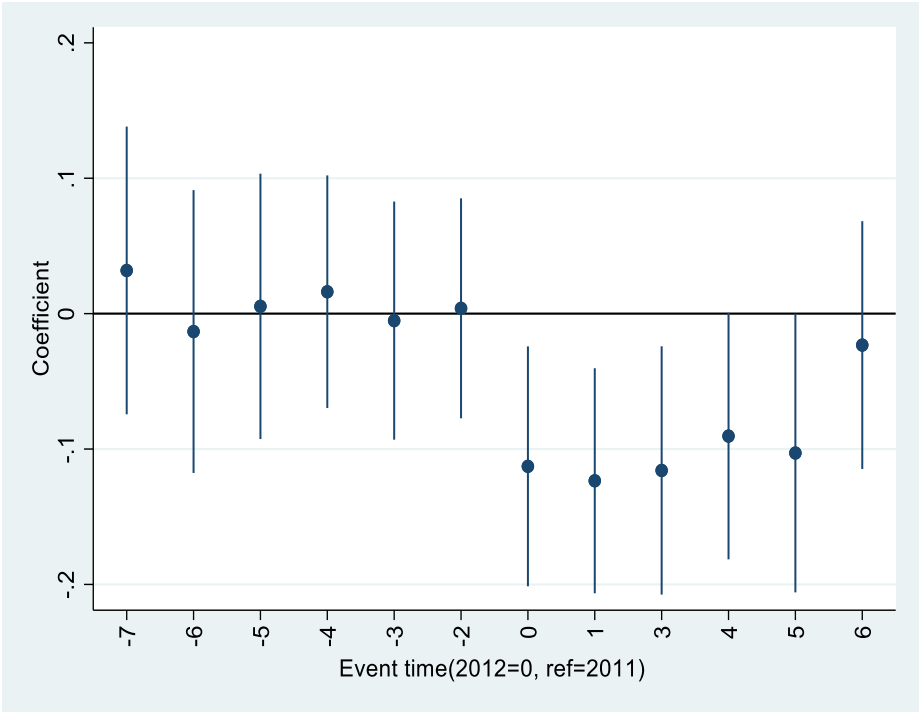


Figure 6: Dynamic Effect of Red Zoning on Wages & Salaries (RRZ areas in 2012)



The DiD analysis presented earlier identifies a single, constant average treatment effect (ATE) for all post treatment periods (a wages and salaries reduction of 6.6% and 10.4% for those who were in RRZ in 2011 and 2012). Here in figures 5-6, we observe the negative effect of relocation right after the forced move. For those who were in the RRZ in 2011, this effect gets larger for two years (until 2013), and then incomes start to recover. The wages and salaries reduction of those who were placed in the RRZ later (in 2012) is somewhat bigger. This larger effect is fairly stable during 2012-2016 and recovers. These patterns indicate that even 7 years after the managed retreat, wages and salaries still have not fully recovered.

5.4. Differences by gender

Table 6-9 showed the regression coefficients for women are larger than men, suggesting that women were more adversely affected than men by the relocation. We can compare the regression coefficients of men with women by testing the null hypothesis Ho: $\beta_f = \beta_m$, where β_f is the regression coefficient for women, and β_m is the regression coefficient for men. We first make a dummy variable for women, then a product of women and post treatment. We rerun regressions with gender dummy for each dependent variable (wages& salaries and total income).

The variable named "females" in table 10 tests the null hypothesis of equal impacts. All of these coefficients, however, are significant, indicating that the women experienced statistically observable larger adverse effects on their incomes (though both men and women have experienced a decrease in their income). Tables with full regression coefficients for sub-groups based on their timing of being RRZ residents and moving are provided in appendix 5.

Table 10. Different Impacts by Gender Following Relocation (LHS: log income)

	Being RRZ residents in 2011		**Being RRZ residents in 2012**	
	Wages& salaries	Total income	Wages& salaries	Total income
	(1)	(2)	(3)	(4)
Females	-0.0558*	-0.0699***	-0.208****	-0.133***
	(-1.93)	(-3.07)	(-3.57)	(-3.07)
Age	0.242****	0.227****	0.243****	0.225****
	(22.90)	(32.75)	(22.45)	(31.92)
Age square	-0.00237****	-0.00205****	-0.00238****	-0.00206****
	(-162.66)	(-173.00)	(-161.29)	(-171.79)
Constant	4.419****	4.682****	4.387****	4.760****
	(11.68)	(18.55)	(11.35)	(18.60)
Observations	1535739	1814952	1505262	1779594
R square	0.601	0.591	0.601	0.591

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses.

6. Caveats and Conclusions

This study analysed the impact of a policy intervention, a 'managed retreat' program that was implemented after the Christchurch earthquake of February 2011. Specifically, it focused on the impact of these relocations on the affected individuals' income. This is the first paper that is able to follow people after they have been relocated and identify what happened to them (in terms of their income). As managed retreat programs are increasingly being considered, as a potentially important tool for climate change adaptation, this identification is becoming more and more important for shaping policy, in New Zealand and elsewhere.

Being red zoned had a negative impact on wages & salaries, and consequently also on the total income of the displaced individuals. The effect for early-career workers was bigger and lasted longer than for their counterparts. Beyond this, the observation that the adverse impact on wages & salaries was bigger than on the total income, suggests that whatever assistance or benefits RRZ residents received from the government, these were not enough to fully compensate for what they lost.

We also found that the adverse relocation effect on women's income was stronger than on men. Here, we observed that the top five sectors where women work (61%) are - public administration & safety, health care & social assistance, education and training, retail trade, and accommodation & food services, whereas 55% of men work in - public administration & safety, manufacturing, construction, retail trade, and professional, scientific, and technical services. Future research may determine to what extent the relocation affected the income of displaced people, differently in different sectors, and whether these differences may account for the distinctions we made between genders.

Some limitations are worth noting. Firstly, we had no access to the actual Red Zone contracts that people signed with the Canterbury Earthquake Recovery Authority (CERA) and the amount of compensation they received – this amount was mostly determined by the value of their house, as previously assessed for property taxes, if they owned their residence. Renters did not receive any assistance whatsoever. Our focus is on the impact of people when they are mandated to retreat/relocate, but it is conceivable that the impact may be different for renters and homeowners, and according to the amount of compensation received. Unfortunately, with our data, we cannot make those distinctions.

Furthermore, there is a large literature that ties social capital (bonding, bridging, and linking social connections – see Aldrich, 2012) to economic outcomes, especially in post-disaster situations (though more generally, too). Presumably, this might be important for managed retreat, since at least in this case whole neighbourhoods were scattered because of the RRZ policy. This was different for the Port Hills area, where the red-zoned properties were quasi-randomly located within neighbourhoods that were not red-zoned (since the red zoning in the Port Hills was associated with the increasing risk of rockfall and slope instability). Ideally, we should have compared the outcomes for Port Hills RRZ with the other groups of RRZ residents. However, the IDI contains only a very small number of people that can be confidently identified as living in the Port Hills RRZ.

Finally, it is important to note that the main conclusion from our findings is that people who are forced to endure a managed relocation suffer also because their income declines. This income decline is found beyond all the other plausible psychological, social, environmental, and economic effects they may otherwise endure because of the relocation itself. As such, it is important to make sure managed retreat programs are designed with this potential loss in mind, and that if these losses do occur, there are mechanisms in place to help those adversely affected.

Appendices

Appendix 1: List of income source categories in the IDI data

In the IDI data, income data are available for the following categories:

- 'W&S' Wages and salaries
- 'BEN' Benefit payments from the Ministry of Social Development (MSD)
- 'CLM' Accident Compensation Corporation (ACC) payments
- 'PEN' Pension payments from MSD
- 'PPL' Paid parental leave payments from MSD.
- 'STU' Student allowance payments from MSD
- 'C00' Total shareholder Salary amount
- 'C01' Company director/shareholder receiving PAYE deducted income.
- 'C02' Company director/shareholder receiving WHT deducted income.
- 'P00' Sole trader income
- 'P01' Partner receiving PAYE deducted income.
- 'P02' Partner receiving withholding tax deducted income.
- 'S00' Sole trader income
- 'S01' Sole Trader receiving PAYE deducted income.
- 'S02' Sole Trader receiving withholding tax deducted income.
- 'S03' Net rent income

Self-employed income source categories.

The self-employment income includes income from one of the source categories below:

- 'C01' Company director/shareholder receiving PAYE deducted income
- 'P01' Partner receiving PAYE deducted income
- 'S01' Sole Trader receiving PAYE deducted income.
- 'C02' Company director/shareholder receiving WHT deducted income
- 'P02' Partner receiving withholding tax deducted income.
- 'S02' Sole Trader receiving withholding tax deducted income.

Appendix 2: Timeline of the managed retreat program

29 March 2011 Establishment of the Canterbury Earthquake Recovery Authority (CERA)

18 April 2011 Passing of the Canterbury Earthquake Recovery Act 2011

23 June 2011 Announcement of the Government purchase offer to owners of insured red zoned residential properties in the Christchurch flat areas. Property owners could accept:

- 100 percent of the 2007 rateable value for land, buildings, and fixtures on the property (any residual insurance claim was then assigned to the Government), or
- 100 percent of the 2007 rateable land value only (and all insurance claims on buildings and fixtures on the property were retained by the owners)

18 August 2011 Announcement that this same offer would be extended to owners of the 940 insured red zoned residential properties in Waimakariri District and also in the Port Hills south-east of Christchurch.

19 August 2011 Mailout of purchase offers to the first 3,000 owners of eligible red zoned properties.

13 September 2012 Announcement of the Government purchase offers for owners of vacant land, and commercial and uninsured properties, in the flat-land residential red zone.

26 August 2013 Decision of the High Court that the government had no prerogative power to create the RRZ, and that the Canterbury Earthquake Recovery Minister had not followed correct statutory procedure.

3 December 2013 The Court of Appeal decided that the decision to red zone parts of Greater Christchurch was lawful, and that there was a rational basis for distinguishing between insured and uninsured properties, but that the 50 percent offer was not in line with the Recovery Act.

13 March 2015 Decision of the Supreme Court that the Government's September 2012 decisions relating to uninsured RRZ property owners and to vacant residential land owners were not lawfully made.

21 April 2015 Announcement of the decision to develop a Recovery Plan, allowing public commentary on the Government offers to owners of red zoned commercial, vacant and uninsured properties. Eventually, uninsured properties were offered the same as insured ones.

Appendix 3. Effects of relocation on wages & salaries by age

Table A3.1: Effects of relocation on wages and salaries by age (LHS: log wages & salaries)

	Age group			
Year	20-29	30-39	40-49	50-60
2004	0.00442	0.00132	0.00132	0.00451
	(0.06)	(0.02)	(0.02)	(0.11)
2005	0.0246	0.0346	0.0346	-0.00467
	(0.37)	(0.69)	(0.69)	(-0.10)
2006	-0.00690	-0.0258	-0.0258	0.0157
	(-0.12)	(-0.54)	(-0.54)	(0.39)
2007	-0.0148	0.0189	0.0189	-0.0119
	(-0.27)	(0.41)	(0.41)	(-0.30)
2008	-0.0327	0.0262	0.0262	-0.0223
	(-0.67)	(0.65)	(0.65)	(-0.60)
2009	0.0511	-0.0164	-0.0164	0.00433
	(1.24)	(-0.44)	(-0.44)	(0.14)
Reference: 2010	-	-	-	-
	-	-	-	-
2011	-0.0367	-0.0491	-0.0491	0.00696
	(-0.83)	(-1.25)	(-1.25)	(0.19)
2012	-0.0618	-0.0681	-0.0681	-0.0434
	(-1.17)	(-1.57)	(-1.57)	(-1.09)
2013	-0.0804	-0.0683	-0.0683	-0.0404
	(-1.63)	(-1.64)	(-1.64)	(-1.17)
2014	-0.138**	-0.0707	-0.0707	-0.103**
	(-2.55)	(-1.44)	(-1.44)	(-2.16)
2015	-0.173****	-0.0656	-0.0656	0.00630
	(-3.32)	(-1.25)	(-1.25)	(0.16)
2016	-0.199****	-0.00673	-0.00673	-0.0149
	(-3.57)	(-0.15)	(-0.15)	(-0.34)
2017	-0.172***	0.0221	0.0221	-0.0384
	(-3.12)	(0.49)	(0.49)	(-0.64)
2018	-0.140***	-0.000739	-0.000739	-0.0364
	(-2.58)	(-0.02)	(-0.02)	(-0.76)
Observations	526371	386844	386844	283386
R square	0.566	0.553	0.553	0.663

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Appendix 4. Event study estimates for effect of managed retreat

Table A4.1. Effect of managed retreat on wages and salaries (LHS: log wages & salaries)

	In RRZ areas in 2011 (Ref.2010) Coefficient (SEs)	**In RRZ areas in 2012 (Ref.2011)** Coefficient (SEs)
Year	(1)	(2)
2005	0.0418	0.0319
	(1.46)	(0.59)
2006	0.00889	-0.0132
	(0.34)	(-0.25)
2007	0.0113	0.00537
	(0.46)	(0.11)
2008	-0.0109	0.0162
	(-0.50)	(0.37)
2009	0.00541	-0.00516
	(0.29)	(-0.12)
2010	-	0.00391
	-	(0.09)
2011	-0.0241	-
	(-1.20)	-
2012	-0.0504**	-0.113**
	(-2.17)	(-2.50)
2013	-0.0662***	-0.123***
	(-3.11)	(-2.91)
2014	-0.0834****	-0.155***
	(-3.37)	(-3.14)
2015	-0.0710***	-0.116**
	(-2.88)	(-2.48)
2016	-0.0720***	-0.0904*
	(-2.94)	(-1.95)
2017	-0.0528**	-0.103*
	(-2.03)	(-1.96)
2018	-0.0401*	-0.0232
	(-1.68)	(-0.50)
Observations	1535739	1504560
R2	0.600	0.601

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Table A4.2: Effect of managed retreat on wages and salaries (LHS: log wages & salaries)

Year	Being RRZ residents in 2011 (Ref. 2010)			Being RRZ residents in 2012 (Ref. 2011)		
	All cohort	*Males*	*Females*	*All cohort*	*Males*	*Females*
2005	0.0418	0.0758*	0.00916	0.0319	0.0974	-0.0423
	(1.46)	(1.88)	(0.23)	(0.59)	(1.37)	(-0.52)
2006	0.00889	0.0221	-0.00647	-0.0132	-0.0223	-0.00820
	(0.34)	(0.62)	(-0.17)	(-0.25)	(-0.31)	(-0.10)
2007	0.0113	0.0313	-0.00946	0.00537	0.00654	0.00114
	(0.46)	(0.93)	(-0.27)	(0.11)	(0.10)	(0.01)
2008	-0.0109	-0.00261	-0.0174	0.0162	0.0256	0.00441
	(-0.50)	(-0.09)	(-0.57)	(0.37)	(0.47)	(0.06)
2009	0.00541	0.0317	-0.0190	-0.00516	-0.0455	0.0372
	(0.29)	(1.18)	(-0.71)	(-0.12)	(-0.78)	(0.54)
2010	-	-	-	0.00391	-0.0176	0.0224
	-	-	-	(0.09)	(-0.32)	(0.37)
2011	-0.0241	0.0166	-0.0633**	-	-	-
	(-1.20)	(0.60)	(-2.18)	-	-	-
			-			-
2012	-0.0504**	0.00260	0.0992***	-0.113**	0.00180	0.232****
	(-2.17)	(0.08)	(-2.93)	(-2.50)	(0.03)	(-3.30)
	-		-			
2013	0.0662***	-0.0145	0.114****	-0.123***	-0.0470	-0.208***
	(-3.11)	(-0.51)	(-3.65)	(-2.91)	(-0.87)	(-3.19)
	-					
	0.0834***		-			
2014	*	-0.0161	0.143****	-0.155***	-0.0780	-0.238***
	(-3.37)	(-0.49)	(-3.94)	(-3.14)	(-1.18)	(-3.27)
	-					
2015	0.0710***	-0.0548	-0.0819**	-0.116**	-0.0417	-0.193***
	(-2.88)	(-1.56)	(-2.38)	(-2.48)	(-0.69)	(-2.72)
	-					
2016	0.0720***	-0.0367	-0.101***	-0.0904*	-0.0685	-0.109
	(-2.94)	(-1.10)	(-2.81)	(-1.95)	(-1.14)	(-1.54)
2017	-0.0528**	-0.0403	-0.0601	-0.103*	-0.0490	-0.159*
	(-2.03)	(-1.12)	(-1.61)	(-1.96)	(-0.78)	(-1.87)
2018	-0.0401*	-0.0244	-0.0523	-0.0232	0.0477	-0.0974
	(-1.68)	(-0.74)	(-1.53)	(-0.50)	(0.84)	(-1.31)
Observations	1535739	764079	771660	1504560	749247	755313
R square	0.600	0.630	0.556	0.601	0.631	0.557

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Appendix 5. Wages & salaries, total income effects on women compared to men

Table A5.1. Wages and salaries effects by gender (Ref: males) (LHS: log wages & salaries)

	Being RRZ residents in 2011			**Being RRZ residents in 2012**		
	All cohort	*Moved in 2011*	*Moved in 2012*	*All cohort*	*Moved in 2012*	*Moved in 2013*
Females	-0.0558*	-0.0993**	-0.0750	-0.208****	-0.269****	-0.0959
	(-1.93)	(-2.22)	(-1.57)	(-3.57)	(-3.68)	(-0.60)
Age	0.242****	0.242****	0.244****	0.243****	0.243****	0.244****
	(22.90)	(22.59)	(22.70)	(22.45)	(22.43)	(22.42)
Age square	-0.00237****	-0.00238****	-0.00238****	-0.00238****	-0.00238****	-0.00238****
	(-162.66)	(-161.62)	(-161.42)	(-161.29)	(-161.10)	(-160.79)
Constant	4.419****	4.422****	4.376****	4.387****	4.393****	4.368****
	(11.68)	(11.55)	(11.42)	(11.35)	(11.37)	(11.25)
N	1535739	1512594	1508058	1505262	1501524	1494606
r2	0.601	0.601	0.601	0.601	0.601	0.601

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Table A5.2. Total income effects by gender (Ref: males) (LHS: log wages & salaries)

	Being RRZ residents in 2011			**Being RRZ residents in 2012**		
	All cohort	*Moved in 2011*	*Moved in 2012*	*All cohort*	*Moved in 2012*	*Moved in 2013*
Females	-0.0699***	-0.0625*	-0.0884**	-0.133***	-0.197****	0.0315
	(-3.07)	(-1.94)	(-2.32)	(-3.07)	(-3.73)	(0.23)
Age	0.227****	0.226****	0.227****	0.225****	0.225****	0.226****
	(32.75)	(32.41)	(32.27)	(31.92)	(31.91)	(31.96)
Age square	-0.00205****	-0.00205****	-0.00205****	-0.00206****	-0.00206****	-0.00206****
	(-173.00)	(-172.09)	(-171.77)	(-171.79)	(-171.61)	(-171.24)
Constant	4.682****	4.722****	4.706****	4.760****	4.762****	4.728****
	(18.55)	(18.62)	(18.42)	(18.60)	(18.61)	(18.40)
N	1814952	1788312	1782186	1779594	1775229	1766778
r2	0.591	0.591	0.592	0.591	0.591	0.592

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

Appendix 6. Job sectors by gender

The data shows that people may not decide to change the sector they are working in because of relocation. However, some high paying jobs may take longer time to find than others in new communities. On the other hand, low paying jobs could lead to a withdrawal from the labor market if people go for other options. Table A6.1 reports the industrial groups and their percentages for the whole cohort. The proportions are similar to both treatment and control group.

Table A6.1. Top 5 job sectors people working in by gender

Females		**Males**	
Job sectors	***Percentages (%)***	***Job sectors***	***Percentages (%)***
Public administration & safety	16.8	Public administration & safety	15.5
Health care & social assistance	15.5	Manufacturing	14
Education and training	10.6	Construction	10.5
Retail trade	10.5	Retail trade	8
Accommodation & food services	7.5	Professional, scientific & technical services	7
Others	39	Others	45

Appendix 7. Self-employment income effects

Table A7.1. Self-employment income effects by timing of being RRZ residents and moving (LHS: self-employment income)

	All cohort		**Male**		**Female**	
	Sum	Log	Sum	Log	Sum	Log
	(1)	(2)	(3)	(4)	(5)	(6)
Being RRZ residents in 2011 & moved						
In 2011	-2782.9	-0.0761	-3419.9	-0.0649	-1333.4	-0.114
	(-1.14)	(-0.58)	(-0.96)	(-0.38)	(-0.42)	(-0.57)
In 2012	496.1	0.0650	-3674.0	0.130	6669.6	-0.0456
	(0.12)	(0.35)	(-0.70)	(0.55)	(1.10)	(-0.15)
Being RRZ residents in 2012 & moved						
In 2012	-11072.9*	-0.294	-13656.7**	-0.230	-4967.6	-0.392
	(-1.93)	(-1.24)	(-2.10)	(-0.79)	(-0.49)	(-0.96)
In 2013	-7130.3	-0.590	-6249.6	-0.00917	-5664.8	-1.186
	(-0.98)	(-1.13)	(-0.93)	(-0.02)	(-0.47)	(-1.61)

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Robust standard errors are shown in parentheses

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