ECONOMIC IMPACT OF NATURAL HAZARDS ON INDIVIDUALS AND BUSINESSES IN NEW ZEALAND

BY

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DECLARATION

This is to declare that this thesis contains no material that has been accepted for the award of any other degree or diploma in any university or equivalent institution. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

APURBA ROY

Dedicated To My Family

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IDI/LBD DISCLAIMER

The results in the first, second, and third papers are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD) managed by Statistics New Zealand. The opinions, findings, recommendations and conclusions expressed in this paper are those of the authors not Statistics New Zealand.

Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022. The results presented in this study are the work of the author, not Stats NZ or individual data suppliers. These results are not official statistics. They have been created for research purposes from the [Integrated Data Infrastructure (IDI) and/or Longitudinal Business Database (LBD)] which [is/are] carefully managed by Stats NZ. For more information about the [IDI and/or LBD], please visit https://www.stats.govt.nz/integrated-data/. The results are based in part on tax data supplied by Inland Revenue to Stats NZ under the Tax Administration Act 1994 for statistical purposes. 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.

All counts presented in this study have had Statistics New Zealand confidentiality rules applied. This includes the random rounding of all counts to base 3. Therefore, the sample counts presented are not exact, and in some cases, aggregating sub-samples will not yield the exact population counts.

ABSTRACT

This thesis contains three essays on the impact of extreme weather events on individual income and business firms in New Zealand. In Chapter Two, we investigate the impact of the extratropical cyclones on individual income, combining the data from Statistics New Zealand's Integrated Data Infrastructure (IDI) and the weather-related insurance claims data from the Earthquake Commission, New Zealand. The study sample covers the administrative longitudinal panel data of all the IRD-registered individual taxpayers between 2010 and 2019. We estimate a set of panel regressions with individual and time-fixed effects to assess the impact of extratropical cyclones on the affected individual's annual income. The study findings show that income from salaries and wages is negatively affected by the cyclones across various specifications. Chapter Three provides an empirical analysis of the impact of floods on individual income in New Zealand between 2000 and 2019. Data from Statistics New Zealand's Integrated Data Infrastructure and Historical Weather Events Catalogue from the National Institute of Water and Atmospheric Research (NIWA) have been used to accomplish the study objective. The impact of floods on the affected individual's annual income was assessed using panel regressions with individual and time-fixed effects. Despite the large floods-induced privately insured damages, floods had no significant impact on individual annual incomes from salary, wage, self-employment, and total income across various specifications. In Chapter Four, we investigate the impact of extratropical cyclones, floods, and wildfires on the profit and business equity of firms operating in New Zealand. We utilize a comprehensive administrative database of all firms from Statistics New Zealand's Longitudinal Business Database from the financial year 2011- 2020 for extratropical cyclones and 2001-2020 for floods and wildfires. We find that the annual profit of extratropical cyclone-affected firms in agriculture, wholesale trade, financial and insurance services, and transportation sectors decreased significantly compared with the unaffected firms in the cyclone year. We also find that floods had no significant effect on the firm's profit, and wildfires had no significant impact on the forestry firms' profit. Besides, the study finding indicates no substantial evidence of the impact of extratropical cyclones, floods, and wildfires on the firms' business equity.

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CHAPTER ONE : INTRODUCTION

Aotearoa New Zealand is highly vulnerable and exposed to a range of extreme weather events, including extratropical cyclones, heavy rains, floods, droughts, and wildfires, because of its unique location in the Southwest Pacific with a maritime and midlatitude climate. Several extratropical cyclones, floods, and wildfires hit New Zealand during the last two decades and caused substantial damage to property and infrastructure, along with a large sum of insurance claim payments. This thesis contains three chapters examining the economic impacts of extreme weather events on individual income and business firms operating in New Zealand. More specifically, Chapter 2 explores the impact of extratropical cyclones on individual income in New Zealand, Chapter 3 estimates the impact of floods on individual income in New Zealand, and the impact of extratropical cyclones, floods, and wildfires on the profit of businesses operating in New Zealand is covered in Chapter 4.

The results presented in the thesis were derived from the Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD) managed by Statistics New Zealand. The IDI is a large database containing de-identified microdata about people and households and aims to include all people living in New Zealand. It contains data on life events, including education, income, benefits, migration, justice, and health. The IDI data come from different sources such as government agencies, Stats NZ surveys, and non-government organizations (NGOs). The data set is then linked together, or integrated, to form the IDI. The IDI has eight broad categories of data: health data, education and training data, benefits and social services data, justice data, people and communities data, population data, income and work data, and housing data. The LBD is another large database containing de-identified microdata about businesses operating in New Zealand. The LBD data come from a range of Stats NZ surveys and government agencies and the data are linked together or integrated to form the LBD. The LBD has data on agriculture, business financials, business practices, employment, innovation, and international trade and tourism. The IDI and the LBD are linked through tax data, enabling longitudinal analysis of events' impact on people and business activity over time.

In Chapter 2, we show the impact of the extratropical cyclones on individual income using administrative longitudinal panel individual income data from the Integrated Data Infrastructure (IDI) and weather-related insurance claims data from the Earthquake

Commission. The individual income data covers all individuals in New Zealand who are registered with the Inland Revenue (IRD) from the tax year 2010 (April 2010–March 2011) to 2019 (April 2019–March 2020). The chapter focuses on the four major extratropical cyclones that occurred in New Zealand during 2017 and 2018 and the corresponding insurance claims after the cyclones to identify the cyclone-affected individuals. The reason is that out of six cyclones between 2010 and 2020, these four cyclones caused around NZD 200 million in private insurance claims and over 17,630 weather-related public insurance claims. The other two cyclones caused approximately NZD 6 million insured claims and only 1,804 weather-related private insurance claims. A panel fixed effects regression specification is used to estimate cyclones' impact on individual incomes. The contribution of this chapter to economic literature is estimating the individual (micro) impact of extratropical cyclones on individual income using rich administrative panel data. The chapter findings indicate that extratropical cyclones caused an average NZD 555 decrease in salary and wage income for the individuals in the extratropical cyclone-affected meshblocks relative to cyclone-affected unaffected meshblocks during the cyclone year. Therefore, the cyclones-induced total income loss (in terms of wage and salary) was NZD 4.6 million. The chapter also estimates the impact of extratropical cyclones across different groups, including gender, ethnicity, and education.

Chapter 3 presents the empirical analysis of the impact of floods on individual income in New Zealand. This chapter also utilizes the individual income data from Inland Revenue (IRD) available at Statistics New Zealand between 2000 and 2019. The cost of disaster list from the Insurance Council of New Zealand (ICNZ) has been used to identify the economically significant floods based on insurance claims payment. The flood-affected location has been identified from the Historical Weather Events Catalogue from the National Institute of Water and Atmospheric Research (NIWA). We use panel fixed effect to examine the impact of the floods on individual incomes. This chapter appears to be the first study regarding the micro-level floods' impact on individual income based on the administrative panel data in New Zealand. The estimated results show that floods had no significant impact on individuals' annual income from salary, wage, self-employment, and total income across various specifications, despite the large floods-induced privately insured damages during the flood year. It also finds no significant impact of floods on the income of different groups, such as gender and education.

Chapter 4 estimates the impact of extratropical cyclones and floods on the profit and business equity of business firms and the impact of wildfires on the profit and business equity of forestry firms in New Zealand, respectively. The firm financial data have been collected from the Annual Enterprise Survey (AES) of the Longitudinal Business Database (LBD), Statistics New Zealand. The Historical Weather Events Catalogue (HWE) from the National Institute of Water and Atmospheric Research (NIWA) combined with already defined weather-related insurance claims data have been used to identify the extratropical cyclones that affected business firms. We used Historical Weather Events Catalogue (HWE) to identify flood-affected business firms. The location of the wildfire-affected areas has been identified from publicly available satellite images and land use map data. The data time for the cyclone impacts analysis between financial tax year 2011 to 2020 and 2001 to 2020 for floods and wildfire impacts analysis. This chapter fills a gap by estimating the firm-level impacts of three extreme weather events (cyclone, flood, and wildfire) using administrative firm-level panel data in New Zealand. The estimated results from the chapter show that the annual profit of extratropical cyclone-affected agriculture, wholesale trade, financial and insurance services, and transportation firms have been negatively affected by the cyclones compared with the unaffected firms. For example, the estimated annual profit loss in the agricultural firms, wholesale trade, and transport firms are NZD 15.34 million, NZD 13.29 million, and NZD 7.67 million, respectively, during the cyclone year. The findings also indicate that floods have no significant effect on the firms' profits, and wildfires have no significant impact on the forestry firms' profits. Additionally, the chapter findings show no significant effect of extratropical cyclones, floods, and wildfires on the firms' business equity.

The IDI and LBD lack perfect geo-location of the people and firms across the country. The meshblock location available for people and firms may have measurement errors. Typically, meshblocks locations are updated once per year by Statistics New Zealand's Geospatial team. To ensure the accuracy and reliability of meshblocks locations, they rely on a range of data sources, including the Census, health and education records, and tax filings, to artery and make the geo-spatial identification as accurate as possible. Therefore, we have to assume that the imperfect geo-location will only lead to random noise in our estimates, instead of a systematic bias.

This thesis comprises three complementary empirical studies that provide insights into how extreme weather events such as extratropical cyclones, floods, and wildfires impact individual income and business firms in New Zealand. All three essays aim at identifying the causal impact of these natural hazards using plausibly exogenous shocks and econometric tools applied to rich administrative panel data. The three chapters cover the analysis of cyclones and individual income (Chapter 2), floods and individual income (Chapter 3), and cyclones, floods, and wildfires and firms' profitability (Chapter 4).

CHAPTER TWO : INCOME AND EXTRATROPICAL CYCLONES IN NEW ZEALAND

Abstract

Aotearoa New Zealand is highly vulnerable to extratropical cyclones because of its unique location in the midlatitude south pacific region. This study empirically investigates the impact of the extratropical cyclones on individual income, combining the data from Statistics New Zealand's Integrated Data Infrastructure (IDI) and the weather-related insurance claims data from the Earthquake Commission. Our sample covers the administrative longitudinal panel data of all the IRD-registered individual taxpayers between 2010 and 2019. We estimate a set of panel regressions with individual and time-fixed effects to assess the impact of extratropical cyclones on the affected individual's annual income. We find that income from salaries and wages is negatively affected by the cyclones across various specifications. Extratropical cyclones also negatively affect the total individual income from wages and salaries, benefit and compensation, and sole tradership. However, we have limited success in identifying individual characteristics influencing the affected people's income level in our study.

2.1 INTRODUCTION

Aotearoa New Zealand is located in the Southwest Pacific with a maritime and midlatitude climate. During the last decade, it has been repeatedly affected by extratropical cyclones. These cyclones produce mass rainfall and strong winds that also generate storm surges and lead to flood events (Lorrey et al., 2014). Most of the damage caused by these cyclones is to property and to horizontal infrastructure (e.g., roads and electricity networks). For example, an extensive slope failure occurred across the Tasman District by extratropical cyclone Gita in 2018, leading to significant damage and closure to State Highway 60 (Prasad & Fenton, 2020). The NIWA (2021) historical weather events catalogue maintains a record of all extratropical cyclones that occurred in New Zealand (NZ). Among these cyclones, the most destructive ones were: Gisele (1968), Bola (1988), Fergus (1996), Drena (1997), Ivy (2004), Debbie (2017), Cook (2017), Fehi (2018), and Gita (2018).

A very small number of existing empirical studies analyse the impacts of extratropical cyclones on the economy. In most cases, the overall cost of extratropical cyclones is assessed at a national or aggregate level. Local or individual-level impacts of extratropical cyclones remain under-studied. The micro-level analysis we describe here enables us to study the heterogeneity of the effects of extratropical cyclones on individual incomes.

This study utilizes administrative individual-level panel data from Statistics NZ's Integrated Data Infrastructure (IDI), matched with weather related-insurance claims data from the Earthquake Commission (EQC). We use this data to analyse the impacts of extratropical cyclones on individual income. We ask: What were the effects of extratropical cyclones on the different types of incomes earned by cyclone-affected individuals in New Zealand? We examine individual earnings from wages and salaries, benefits, self-employment, and income from all other sources. We use a fixed-effect panel regression model with annual income data for all individuals in New Zealand.

The rest of the paper is structured as follows: Section 2 provides a brief description of the existing literature on extratropical cyclones and their impacts in high-income countries. Section 3 details the data sources and the empirical models used. Section 4 presents the results, and Section 5 concludes with further observations.

2.2 LITERATURE REVIEW

A cyclone is a weather system where winds circulate a central low-pressure atmospheric area. There are various types of cyclones depending on their characteristics and location, such as tropical cyclones, extratropical cyclones, and tornadoes. Cyclones are the world's costliest natural weather disaster in terms of financial destruction (Ginis, 2021). Extratropical cyclones are also known as mid-latitude cyclones (Chang et al., 2002; Raible et al., 2021). These weather systems bring a wide range of weather variability, including massive precipitation as well as strong winds, and can cause extensive socioeconomic damage (Browning, 2004; Catto et al., 2012; Hawcroft et al., 2012; Pfahl & Wernli, 2012). Sometimes an extratropical cyclone is a tropical cyclone that moves into the midlatitude regions. This is particularly common in the West Pacific and the North Atlantic Oceans (Ginis, 2021). Through this transformation, tropical cyclones change their original structure and characteristics and turn into cold-cored systems. This transformation generates a storm with strong winds and intense rainfall, though the rainfall, on average, is still not as intense as that produced by tropical cyclones (Bieli et al., 2020; Evans et al., 2017; Frame et al., 2017; Jones et al., 2003). Most coastal high-income countries are situated in the mid-latitude regions and several are thus exposed to extratropical cyclones.

2.2.1 Extratropical Cyclone in the United States

Hurricane Sandy, one of the most destructive extra-tropical cyclones in the history of the United States (US), hit the North Eastern seaboard on 29th October 2012. Sandy affected 24 states with record-level storm surges in New Jersey, New York, and Connecticut (Babson et al., 2020). Using business micro-datasets on the establishment, business, employment, sales revenue, and property characteristics, Meltzer et al. (2021) identified the impact of Sandy-induced floods on New York City retail business. They found that retail businesses dependent on local customers faced the most adverse hit to their revenue. After Sandy, retail businesses in the higher inundation blocks experienced an 11 percent increase in the probability of closure relative to those located in less inundated areas. The revenue of the business establishments situated at the high-surge blocks declined by 9 percent compared with the business establishments located in the low-surge blocks, in the aftermath of the storm.

Petkova et al. (2018) used a household-level survey administered in New York City (NYC) to examine the factors influencing the long-term recovery of Sandy-affected residents. The authors concluded that social and economic factors, such as health status, displacement, and household income played a crucial role in recovery. They also found that many residents of NYC affected by Sandy did not recover three years after the storm. In a micro-level study on households at the Rockaway Peninsula of NYC, Subaiya et al. (2019) reported that the employment status of nearly one-third of households had changed due to the storm, resulting in job loss (44 percent) and loss of pay (40 percent).

Recently, Hurricane Ida, a category four hurricane, made landfall in Louisiana on August 29, 2021. Risk modeling projected that insured costs could be between USD (31-44) billion (Scism, 2021). It moved towards the northeast and caused devastating floods to New York, New Jersey, Pennsylvania, and Connecticut. The estimated flood-induced insured commercial and residential property damages in the US Northeast region could be between USD (5- 8) billion, while the insured loss was estimated to be USD (11 - 16) billion (Baird-Remba, 2021).

2.2.2 Extratropical Cyclone in Europe

European winter windstorms, typically generated by extratropical cyclone systems, are the second most damaging natural hazard after floods in Western and Central Europe. These mid-latitude windstorms generally form in the North Atlantic and can lead to large-scale disasters (Fink et al., 2009; Haas & Pinto, 2012; Karremann et al., 2014; Priestley et al., 2018; Schwierz et al., 2010; Sharkey et al., 2020). Europe has experienced these windstorms initiated from extratropical cyclones quite frequently (Goldman et al., 2014). Some of these major storms were Storm David/Friederike (January 2018), Xavier (December 2013), Xynthia (February 2010), Klaus (January 2009), Kyrill (January 2007), and Lothar (December 1999) (Gardiner et al., 2010; Insurancejournal, 2018).

Despite having a significant impact on European economies, these windstorms remain understudied (Koks & Haer, 2020). A few studies on household- or individual-level socioeconomic impacts of these windstorms in Europe using microdata or survey data are available in the current literature. A couple of studies only reported the national or regional level aggregated economic loss or damages. For instance, according to the French insurance association, windstorms Lothar (1999) and Martin (1999) caused a loss of 6.9 billion Euros, and Klaus (2009) resulted in a 1.7 billion Euro loss due to wind-related property loss in France (Peiris & Hill, 2012). Some windstorms hit south-western Europe in the winter season of 2009-10. Among the windstorms, Xynthia (February 2010) affected numerous regions, including

Portugal and Spain, and some parts of Belgium, France, and Germany. The total financial loss was estimated at EUR 3.6 billion (Liberato et al., 2013). In France, the storm's direct loss amounted to more than EUR 2.5 billion (Genovese & Przyluski, 2013). von Möllendorff and Hirschfeld (2016) used a German Socioeconomic Panel Study (SOEP) to estimate the welfare effects of extreme events, including the Elbe flood (in 2002) and the storm Kyrill (in 2007). They used individual-level panel data and found that both events were responsible for a small but significant decrease in self-reported individual life satisfaction. The storm effects were short-term, but the effects of the flood remained for much longer. Another extratropical cyclone, Katia, impacted the British Isles in September 2011, causing USD 157 million of damage (Anfuso et al., 2020).

2.2.3 Extratropical Cyclone in Japan

The location of Japan in the western North Pacific Ocean basin makes the country highly exposed to extratropical systems. More than fifty percent of the typhoons, including the costliest typhoons landing in Japan, have undergone extratropical transitioning (Joseph, 2016; Loridan et al., 2014). Some of the costliest typhoons that hit Japan in the last decades are Typhoon Hagibis (2019), Faxai (2019), Jebi (2018), Trami (2018), Songda (2004), Mireille (1991), Vicki (1998), Bart (1999), Flo (1990), Sarah (1986), and Vera/Ise Bay Typhoon (1959). These typhoons caused significant damage to property and infrastructure in the affected areas. Okubo and Strobl (2021) have examined the survival, and survivor performance of the firms located in the Ise Bay Typhoon affected Nagoya City in the Ise Bay region. They used historical unique firm-level data, and flood inundation maps to study the impacts of the heterogenous damage across firms. Their findings indicate that after the flood, the survival strength of retail and wholesale firms was lower than the firms in the manufacturing sector. The research finding also concludes heterogenous firm performance across the sectors, such as increased capital growth in manufacturing sectors and decreased sales and capital growth in local flood-affected wholesale sectors. However, for the firms in the retail sectors, no regional spill-over effects were observed.

2.2.4 Extratropical Cyclones in New Zealand

The geographic location of New Zealand makes it vulnerable to tropical cyclones formed in the South Pacific. At least one out of ten tropical cyclones from the South Pacific hits New Zealand, mainly in February or March. The Meteorological Service of New Zealand Ltd

(MetService) follows the Australian tropical cyclone intensity scale guidelines for categorizing these cyclones (Table 2.1 in the Appendix).

Several extratropical cyclones have passed over New Zealand in recent years and caused considerable property and infrastructure damage. In terms of insured loss, four notable recent extratropical cyclones were Cook (2017), Debbie (2017), Gita (2018), and Fehi (2018). The combined insured cost of these four events was nearly NZD 200 million, surpassing the combined loss from all the other cyclones after 1980 (Insurance Council of New Zealand, 2021). This paper focuses on these four cyclones; a description of these cyclones follows in the next section.

2.3 METHODOLOGY

2.3.1 Data Type and Source

The primary data source we use is Statistics New Zealand's Integrated Data Infrastructure (IDI). It includes all individuals in New Zealand who are registered with the Inland Revenue (IRD) department (i.e., everyone who has declared any amount of income). Income from all types of activities is recorded in the annual IRD tax forms that are completed annually; this data is then linked to other unit records by Statistics NZ in the IDI. We consider tax years 2010 (April 2010-March 2011) to 2019 (April 2019-March 2020).

The New Zealand Historic Weather Events Catalogue (HWE) of the National Institute of Water and Atmospheric Research (NIWA) contains a comprehensive and detailed list of all extreme weather events in New Zealand (NIWA, 2021c). The list includes a variety of weather events (extratropical cyclones, storms, floods, strong wind, heavy rain, and heavy snowfall) from 1996 to 2019, with the intensity of the events, their dates and the affected regional councils. Fifteen extratropical cyclones are included in this list (see Table 2.3 in Appendix). A total of six extratropical cyclones affected the country from 2010 to 2019. Four major extratropical cyclones hit the regions between 2017 and 2018. Extratropical cyclones Debbie (3^{rd} April) and Cook (11^{th} April) hit in 2017, and Extratropical cyclones Fehi (1^{st} February) and Gita (20^{th} February) struck in 2018. During our sample period, there were two other extratropical cyclones: Pam (15^{th} March 2015) and Lusi (14^{th} March 2014). According to the Insurance Council New Zealand, the total amount of private insurance claims from Pam and Lusi was NZD 5.8 million, and the number of weather-related insurance claims from the public insurer was very small. On the contrary, the total amount of private insurance claims from the extratropical cyclones Debbie, Cook, Fehi, and Gita reached nearly NZD 200 million, including 17,630 weather-related public insurance claims after the cyclones. Further details about the cyclones are found in Appendix Table 2.2. Hence, our study concentrates on evaluating the impact of these four extratropical cyclones that happened to affect New Zealand in 2017 and 2018 (see Figure 2.1 in the Appendix).

2.3.2 EQC Insurance Claims

The Earthquake Commission (EQC) is the government-owned hazards insurance provider for residential property. The EQC only covers land damage for flooding events or storms. It also covers buildings (and other appurtenant structures, retaining walls, etc.) for landslips (the only weather hazard that is fully covered), and the non-weather hazards like tsunamis, earthquakes, and volcanic eruptions.

The EQC weather-related insurance claims dataset we use identifies each claim by the geographic location of damage in terms of geo-coordinates (rounded by 70m to protect privacy). We consider the claims that were made three days before and after the occurrence date of each extratropical cyclone to detect the cyclone-affected meshblocks (meshblocks vary in land area but typically contain 40-60 houses). We identify those meshblocks where at least two or more weather-related insurance claims were registered, and that are also located in the cyclone-affected region, as identified in the NIWA/MetService list of extreme weather events.

We identify 227 meshblocks (with at least two cyclone-related insurance claims), 98 meshblocks (with at least three claims), 51 meshblocks (at least four claims), 39 meshblocks (at least five claims), and 36 meshblocks (at least six claims) (see Figure 2.2 in the Appendix). Our main results are reported for the 'at least two claims' meshblock group.

2.3.3 Individual Income Data (IDI, Statistics New Zealand)

Individual-level income from different sources has been collected from annual tax filings which report income. According to Inland Revenue (IR) guidelines, an individual receiving more than NZD 200 a year (before tax) needs to file an income tax return before the end of the tax year. The income information of all tax filers, usually aged 15+, is available in the IDI. Every individual is identified in terms of their residential address within a meshblock (to preserve anonymity, only the meshblock information is provided. Given the nature and characteristics of individual income types, we grouped income into four categories (further explanations of each income type are provided in Table 2.4 in the Appendix):

1. Wage & Salary: Total yearly earnings from all wages and salaries (WAS)
2. Benefit & Compensation: Includes the summation of earnings from ACC payments (ACC is the public insurer for accidents and disability payments) and benefits (BEN) provided by the Ministry of Social Development.

3. Self-employment: This category is composed of yearly earnings from sole proprietorships or enterprises.[1]
4. Wage, Benefit & Self-employment: This sums up the previous three categories.

The individual income is provided for each tax year, starting from 1st April to 31st March. The dates of the four extratropical cyclones we focus on, occurred in two calendar years (2017 to 2018), but conveniently they all fall within the 2017 tax year (1/4/2017 to 31/3/2018).

2.3.4 Estimation Methods

We assume that individual income is influenced by time-invariant factors including education, expertise or skills, and geographic location. Including individual fixed-effects can control for any time-invariant determinants of income. Besides, we also include time fixed-effects to control for time-varying effects that are common to the population being examined (such as the macroeconomic business cycle). We thus estimate the following equation:

$$\boldsymbol{Y_{it}^{d} = \sum_{c=2014}^{2019} \beta_c D_c + \lambda_t + \mu_i + \varepsilon_{it} \dots (1)}$$

where Y_{it}^{d} is the income of individual *i*, in time *t* of category *d* (salary, self-employment, etc.). Here, the cyclone-affected meshblocks are denoted by *D*, while *c* denotes the year, so that the coefficient β_c denotes the income of individuals residing in the affected meshblock in the respective year *c* (2014-2016 before the cyclone, 2017 is the year of the cyclones, and 2018-2019 are the following two years). For instance, $D_{2017} = 1$ for individuals who lived in the cyclones affected meshblock in 2017 and $D_{2014} = 1$ for people who lived in a cyclone affected meshblock in 2017 times a dummy variable for the year 2014. λ_t is a vector of year dummies to capture the year fixed effects from 2010 to 2019. The μ_i represent individual fixed effects. The ε_{it} is an idiosyncratic error term (ε_{it}~i.i.d). We calculate clustered standard errors at the individual level, which are robust both to heteroskedasticity and to correlation over time for an individual (Stock & Watson, 2020). We estimated four regressions based on the four income categories using Equation 1 for meshblocks that have at least two insurance claims.

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[1] Four types of earnings from sole proprietorship are included. These earnings come from income received by the individuals from sole trades or self-employment net profits (S00), earnings from sole traders paying themselves a wage and salary (S01), earnings from sole traders paying themselves withholding payments (S02), and earnings from sole traders receiving rental income (S03).

2.4 RESULTS AND DISCUSSION

2.4.1 Summary Statistics

Table 2.1 describes the mean, standard deviation, and number of observations of different individual income categories from the extratropical cyclone-affected meshblocks and control meshblocks in 2017 and 2018. Columns 1 and 3 summarize the individual income from the affected meshblocks of at least two weather-related insurance claims. Columns 2 and 4 summarize the remaining unaffected meshblocks. Comparing average yearly individual incomes between affected meshblocks and control meshblocks shows very little difference between the two domains. There is also clear evidence that individual annual average income from all categories except income from self-employment increased slightly from the tax year 2017 to 2018. Similar notation is also visible for the individual income within the affected meshblocks simultaneously (columns 1 and 3). A graphical presentation of the average income from the affected and non-affected meshblocks has been shown in Appendix Figure 2.3. Table 1 reveals that, on average, income from benefits and compensation was the lowest amount in the income categories.

2.4.2 Estimation Results

We begin this segment by presenting the regression results of the impact of extratropical cyclones on the different incomes of individuals in the affected meshblocks compared with the individuals' income from the non-affected meshblock. We show both the regression results using the absolute value and the standardized regression coefficients (mean 0, standard deviation 1 outcome). The reason for reporting standardized regression coefficients is to compare the strength of the impacts of explanatory variables on the dependent variable.

2.4.3 Impact of Extratropical Cyclone on Individual Income (At Least Two Weather-related Insurance Claims)

Table 2.2 shows regression results of the impact of extratropical cyclones on individual incomes in the affected meshblocks. From Columns 1 to 4, the estimated coefficients of the dummy variables are presented. In Column 1, the estimated coefficient of the dummy variable (D_{2017}) is negative and statistically significant at a 5 percent level, where the dependent variable is the individual annual income from wage and salary. It indicates that, by adjusting other time-invariant individual fixed effects, income from wages and salaries on average decreased by NZD 555 for the individuals in the extratropical cyclone-affected meshblocks relative to those who were not in the same meshblocks in 2017 (Column 1). The estimated coefficients before and after the cyclone year 2017 were statistically insignificant, implying no significant change in income during these years. On average, total economic loss due to extratropical cyclones in terms of wage and salary reached NZD 4.6 million in 2017 (Appendix Figure 2.4). The estimated coefficient of self-employment income (Column 3) in the cyclone year is 235.4, implying that individuals in the cyclone-affected areas earned NZD 235.5 from self-employment compared with those in cyclone-unaffected areas. However, the income coefficient is statistically insignificant. However, the estimated coefficient from self-employment in Column 3 is positive and statistically significant in 2019. Although this income increase occurred two years after the cyclone events, the possible reason for increasing income from a self-employed job maybe that construction and rebuilding jobs increased in the affected area after cyclones and provided additional income opportunities for those employed in this sector. The regression coefficients in Column 4 (Wage, Benefit & Self-employment) were negative but statistically insignificant. A graphical representation of the regression coefficients is presented in Appendix Figure 2.5. From Figure 2.5, it is visible that income from wage and salary was positive on average before the cyclone, and it suddenly declined after the cyclone. The other income type follows the same trend except for self-employment.

Table 2.1: Summary Statistics of Individual Income

	2017		**2018**	
	Affected by Extratropical Cyclone in 2017) (1)	**Control Meshblocks (2)**	**Affected by Extratropical Cyclone in 2017) (3)**	**Control Meshblocks (4)**
Wage & Salary				
Mean	31,580.39	32,248.83	33,021.3	33,432.93
Std. Dev.	41,469.01	42,825.84	41,646.91	43,969.11
Observations	8,295	2,095,032	8,739	2,189,967
Benefit & Compensation				
Mean	1,603.34	1,587.92	1,610.37	1,553.20
Std. Dev.	4,925.11	5,141.84	5,009.12	5,148.15
Observations	8,295	2,095,032	8,739	2,189,967
Self-employment				

Mean	2,549.01	2,425.94	2,330.54	2,422.69
Std. Dev.	19,030.13	20,049.09	16,783.67	20,424.52
Observations	8,295	2,095,032	8,739	2,189,967
Wage, Benefit & Self-employment				
Mean	35,732.75	36,262.7	36,962.23	37,408.84
Std. Dev.	43,635.16	45,336.36	43,079.88	46,577.47
Observations	8,295	2,095,032	8739	2,189,967

Note: Income values are expressed in New Zealand Dollars. The cyclone-affected meshblocks are based on at least two weather-related insurance claims.

Table 2.2: Impact of Extratropical Cyclone on Income at Individual Level

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	245.3	7.662	26.25	279.2
	(189.8)	(38.16)	(112.1)	(205.1)
D_{2015}	38.99	-27.04	91.93	103.9
	(219.7)	(38.54)	(110.4)	(226.9)
D_{2016}	-209.2	-22.29	191.4	-40.06
	(239.1	(41.93)	(144.9)	(257.8)
$D_{2017}^{\dagger}$	-555.1**	-2.006	235.4	-321.8
	(247.0)	(40.48)	(158.0)	(273.7)
D_{2018}	-349.8	20.37	112.6	-216.8
	(251.1)	(41.02)	(133.3)	(267.5)
D_{2019}	-493.6	-38.51	416.3**	-115.8
	(304.2)	(44.51)	(187.0)	(330.6)
R^2 (within)	0.037	0.0002	0.002	0.039
R^2 (Between)	0.0178	0.0011	0.0011	0.0231
Number of individuals	2,379,936	2,379,936	2,379,936	2,379,936
Number of observations	19,332,492	19,332,492	19,332,492	19,332,492

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance

claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

We also examined the impact of the extratropical cyclone on individual incomes by changing the measurement unit of the income variables, more specifically using the standardizing regression equation using the Z-score. The estimated standardized regression coefficients are presented in Appendix Table 2.5. The estimated standardized coefficient of the dummy variable (D_{2017}) in Column 1 is negative and statistically significant. This result is consistent with the absolute value regression coefficient of the variable. Individuals from the extratropical cyclone-affected meshblocks experienced 0.014 standard deviations decrease in income from wage and salary than those who lived outside the affected meshblocks. On the other hand, income from self-employment is found to increase by 0.023 standard deviations in the affected area during the cyclone years. Before cyclones, income coefficients show no significant change. Figure 2.6 in the Appendix shows the graphical presentation of the standardized coefficients.

2.4.4 Impact of Extratropical Cyclone on Above-Median and Below-Median Individual Income

2.4.4.1 At Least Two Weather-related Insurance Claims from a Meshblock

We next examine whether the impact of extratropical cyclones on individual incomes is different for differing levels of income. Specifically, we divide the population into two groups - above-median and below-median income, based on the median income threshold for total income category for the individuals living in the cyclone-affected meshblocks in 2016. We can thus compare the evolution of below-median income individuals affected by the cyclones compared to below-median income individuals unaffected by the event (and similarly for the above-median group). Table 2.3 and Table 2.4 present the regression results containing above-median and below-median income groups, respectively. The standardized regression results of the above-median income (Appendix Table 2.6) and below-median income (Appendix Table 2.7) groups are reported in the appendix.

Individuals who belong to above-median income groups experienced a negative shock on their earnings from wages and salaries in the cyclone year and the following consecutive year (Table 2.3). The regression results presented in Table 2.3 also provide evidence that earnings from Wage, Benefit, and Self-employment decreased from 2017 to 2019, although the income coefficients of 2017 are statistically insignificant. The results from the standardized regression provided in Appendix Table 2.6 indicate similar statistical evidence that the cyclones had a negative impact on income from wage and salary. However, the estimated coefficient of the dummy variable (D_{2017}) at Column 3 in Table 2.3 is positive and statistically significant. It indicates that cyclones had a positive impact on income from self-employment income for above-median income groups. On the other hand, there is a lack of sufficient statistical evidence to conclude the adverse effects of the cyclone on the below-median income groups. We found no statistically significant indication for any income category negatively affected by the cyclones (Table 2.4, Appendix Table 2.7).

Table 2.3: Impact of Extratropical Cyclone on Above-median Income at Individual level

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	200.3	-60.66	-24.71	114.9
	(279.2)	(45.77)	(236.3)	(322.1)
D_{2015}	82.16	-80.54	-8.158	-6.542
	(315.6)	(59.47)	(207.8)	(324.8)
D_{2016}	-180.8	-54.44	269.4	34.16
	(335.7)	(51.34)	(238.2)	(345.8)
$D_{2017}^{\dagger}$	-518	-57.36	424.7*	-150.6
	(333.1)	(52.66)	(254.6)	(356.9)
D_{2018}	-355	36.05	181.8	-137.2
	(333.6)	(58.12)	(223.8)	(344.5)
D_{2019}	-552.3	-98.63	752.7**	101.8
	(426.8)	(67.11)	(303.5)	(434.4)
R^2 (within)	0.094	0.0004	0.0037	0.105
R^2 (between)	0.012	0.00	0.0007	0.015
Number of individuals	1,562,673	1,562,673	1,562,673	1,562,673
Number of observations	9,530,400	9,530,400	9,530,400	9,530,400

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income (above-

median) from the tax year 2010-2019. The median income is calculated from total individual income from the extratropical cyclone-affected meshblocks in 2016. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 2.4: Impact of Extratropical Cyclone on Below-median Income at Individual level

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	44.93	7.79	-5.12	47.61
	(78.61)	(44.76)	(51.1)	(91.57)
D_{2015}	-90.28	-13.21	-22.09	-125.6
	(81.97)	(51.79)	(52.02)	(97.58)
D_{2016}	34.54	2.70	6.02	43.26
	(82.82)	(55.29)	(52.52)	(100.0)
$D_{2017}^{\dagger}$	61.81	21.66	58.92	142.4
	(83.16)	(53.27)	(49.09)	(98.89)
D_{2018}	51.92	-0.481	35.78	87.22
	(80.63)	(51.86)	(47.55)	(96.66)
D_{2019}	37.03	-45.59	67.6	59.04
	(85.32)	(60.1)	(63.21)	(110.4)
R^2 (within)	0.0005	0.0006	0.0005	0.0012
R^2 (between)	0.0155	0.0023	0.000	0.0246
Number of individuals	1,865,736	1,865,736	1,865,736	1,865,736
Number of observations	9,802,092	9,802,092	9,802,092	9,802,092

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income (below-median) from the tax year 2010-2019. The median income is calculated from total individual income from the extratropical cyclone-affected meshblocks in 2016. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

2.4.5 Impact of Extratropical Cyclone Across Different Groups

The effects of extreme weather events such as extratropical cyclones on human society vary across different social factors, including gender, education, and ethnicity. We have investigated the impact of extratropical cyclones on individuals in the affected meshblocks based on their sociodemographic characteristics. We have distinguished individuals based on gender, ethnicity, and highest educational qualification, as noted in the 2018 census data. Table 2.5 highlights the cyclone impacts on selected income of individual groups and while additional detailed analysis is provided in the Appendix.

Gender

We have estimated the impact of extratropical cyclones on the incomes of males and females from the cyclone-affected meshblocks, compared with the same gender in the non-affected meshblocks. Table 2.5 shows that income coefficients of wage and salary for men have declined after the cyclone. On average, a male income earner in the cyclone-affected areas experienced NZD 876 loss in income due to the extratropical cyclones in 2017 relative to other males not in the cyclone areas. The decrease in income continued for the next two years for the male group. It is seen from Column 1 that the wage and salary income of the male group who were affected by cyclones faced NZD 780.8 and NZD 1022 for the years 2018 and 2019, respectively.Income coefficients of self-employment are positive and significant between 2015 and 2017. The income increase in the pre-cyclone period does not provide strong evidence of the cyclone-induced positive effect on self-employment income after the cyclone period. The income from self-employment of the female group is negative and statistically insignificant, as shown in Table 2.5, Column 3. It might be the case that wage and salary of the female group were also negatively affected by the cyclones, but this evidence is not robust and isnot statistically significant. The other income categories exhibit no statistical change before and after the cycle (Appendix Table 2.8) for either gender. Besides, we found no statistical evidence of decreasing income for females from self-employment and total income categories after the cyclones (Appendix Table 2.9).

Table 2.5: Impact of Extratropical Cyclone on Selected Individual Groups

	Male		Female	
	Wage & Salary	**Self-employment**	**Wage & Salary**	**Self-employment**
	(1)	**(2)**	**(3)**	**(4)**
D_{2014}	259.7	158.8	211.0	-31.99
	(303.2)	(217.1)	(226.4)	(92.18)
D_{2015}	-102.8	416.2**	189.2	-142.1
	(345.1)	(203.2)	(267.1)	(105.5)
D_{2016}	-491.3	517.5**	116.8	-127.5
	(387.7)	(254.5)	(278.5)	(139.8)
$D_{2017}^{\dagger}$	-876.2**	613.5**	-201.9	-148.1
	(393.6)	(281.5)	(296.4)	(145.3)
D_{2018}	-780.8**	342.3	139.6	-110.4
	(392.7)	(234.8)	(313.7)	(129.2)
D_{2019}	-1,022**	968.1***	59.16	-150.2
	(483.7)	(331.6)	(363.6)	(174.1)
R^2 (within)	0.038	0.0017	0.039	0.0024
R^2 (between)	0.0193	0.0017	0.0201	0.0007
Number of individuals	1,167,486	1,167,486	1,212,450	1,212,450
Number of observations	9,536,529	9,536,529	9,795,960	9,795,960

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Ethnicity

We identified individuals based on ethnicities (European, Maori, Pacific, Asian, and Middle East, Latin American and Africa - MELAA). The estimated regression results provide statistical evidence that Europeans incurred NZD 513 loss in income from wage and salary due to the 2017 cyclones (Appendix Table 2.10). The estimated income coefficients from other sources of income show no statistical change for Europeans. The income coefficients are also negative for Maori in 2017 and the preceding year (Appendix Table 2.11). It is unclear whether the decrease in income in the cyclone year is due to the impact of cyclones or the influence from the previous year. In the rest of the ethnic communities, Pacific, Asian, and MELAA, we found no statistical evidence for any negative impacts of the cyclones on incomes (Appendix Table 2.12-2.14).

Education

Based on the highest educational qualification achieved, we categorized the individuals according to the Ministry of Education qualification levels: tertiary education certificates (level 1-4), diplomas (level 5-6), bachelor degree (level 7), and post-bachelor (graduate) education (level 8-10). The estimated regression coefficients are presented in Appendix Table 2.15-2.19. We found that income from wage, salary and benefits, and the total income of people with no tertiary education at all were negatively affected by the extratropical cyclones in 2017 (Appendix Table 2.15). In addition, the self-employment income of individuals with post-bachelor qualifications increased by NZD 930 in 2017 (Appendix Table 2.19). For the rest of the educational groups, we found no evidence of any effects of cyclones on incomes.

2.5 CONCLUSION

This study has examined the impacts of extratropical cyclones on individual incomes in the cyclone-affected regions by using administrative (inland revenue department) annual income and a panel regression approach (with individual and time fixed effects). We match this income data with weather-related insurance claims from the affected meshblocks, we have investigated the economic impacts of extratropical cyclones at a micro-level.

Four large extratropical cyclones hit various parts of New Zealand between 2017 and 2018. Some regions were affected by more than two cyclones during the periods. These extratropical cyclones brought significant economic loss and damages to individuals residing in the areas. Our estimated results confirm that individual income from wages and salaries was negatively affected by the cyclones in the regions affected compared with the non-affected areas. In addition, we have also no found statistical evidence that individuals in both above-median income groups and below-median income are adversely affected by the cyclones. This study is the first endeavor to use administrative individual-level panel income data to assess the cyclone impact in New Zealand. The findings of the paper also give concrete evidence of the microlevel socioeconomic impact of the extratropical cyclone. Although there was the availability of other longitudinal individual-level data, our analysis only focused on individual incomes. Our study provides an in-depth insight into the microlevel impact of extratropical cyclones on individual income in New Zealand.

APPENDIX

Appendix Table 2.1: Category of Tropical Cyclone

Category	Known as	10-minute Mean Wind Speed	Maximum 3-second Gust Speed
1	Tropical Cyclone	34-47 knots (63-87 km/h)	Less than 125 km/h
2	Tropical Cyclone	48-63 knots (89-117 km/h)	125-164 km/h (Destructive winds)
3	Severe Tropical Cyclone	64-85 knots (119-157 km/h)	165-224 km/h (Very destructive winds)
4	Severe Tropical Cyclone	86-107 knots (159-198 km/h)	225-279 km/h (Very destructive winds)
5	Severe Tropical Cyclone	Over 107 knots (Over 200 km/h)	Over 280 km/h (Very destructive winds)

Source: Adapted from MetService (2021).

Appendix Table 2.2: Description of Major Four Extratropical Cyclones in New Zealand

Title	Description
Extratropical Cyclone Gita	Cyclone Gita was initially formed from a monsoon trough in the south pacific in early February 2018. After that, it moved towards the south by crossing the tropics and made landfall in New Zealand after transitioning into an extratropical cyclone between February 20-22. It brought heavy rainfall and strong winds up to 140 km/h to some places (Daly, 2018). Extratropical cyclone Gita brought damages to the Tasman region and West Coast, Wellington, Taranaki, and Canterbury. The total amount of private insurance claims reached NZD 35.6 million (Insurance Council of New Zealand, 2021; NIWA, 2018b).
Extratropical Cyclone Fehi	Cyclone Fehi originated in the Australian Region in late January 2018 and approached the South Pacific basin on the 28th as a subtropical cyclone. After that, it continued to move south and southwest and transitioned into an extratropical cyclone when it reached New Zealand on the 1st of February. It came with a strong wind and heavy rainfall, causing floods to several regions of the country. Mostly affected regions were the West Coast, Tasman, Nelson, Wellington, and Otago. The damage and cost of the cyclone in terms of private insurance claims reached NZD 45.9 million (Insurance Council of New Zealand, 2021; NIWA, 2018a).
Extratropical Cyclone Cook	Cyclone Cook was formed from a tropical disturbance in the early April of 2017. The system turned into a category one cyclone on April 8 and hit New Caledonia. It moved to the south-southwest, transitioned into the extratropical cyclone, and reached New Zealand on April 13. Extratropical cyclone Cook hit Bay of Plenty, Northland, Auckland, Hawke's Bay, Gisborne, and Waikato regions with heavy rain and strong winds. The total amount of private insurance claims was NZD 17.2 million (Insurance Council of New Zealand, 2021; NIWA, 2017b).

Extratropical Cyclone Debbie	Cyclone Debbie was recognized as a low-pressure system that originated in the Coral Sea in the 3rd week of March 2017. It gained strength and turned into a category three tropical cyclone when it first made its landfall in Queensland, Australia, on the 28th of March. A week later, cyclone Debbie's remnants crossed New Zealand (3rd-6th April) after losing its tropical characteristics. It caused severe floods in several parts of the country. A town named Edgecumbe of the Bay of Plenty region was evacuated to avoid risk from flooding (Ward, 2017). Besides, part of Auckland, Manawatu-Wanganui, Hawke's Bay, and Canterbury were severely affected by the cyclone. The total amount of private insurance claims reached NZD 91.46 million (Insurance Council of New Zealand, 2021; NIWA, 2017a).

Appendix Table 2.3: List of Extratropical Cyclones in New Zealand (NZ) 2018-1996

Date	Title	Cyclone Affected Regions, New Zealand
20-2-2018	Extratropical Cyclone Gita	Tki:2w, Wgn:3w, Tas:3r3w, Wst:3w, Cny: 1r
01-2-2018	Extratropical Cyclone Fehi	Ald:3r, Wgn: 3r 3w, Tas: 3r 3w, Wst: 3r 1w, Ota: 2r
11-04-2017	Extratropical Cyclone Cook	Nld:2r, Wko:3r, Bop:2w, Gsb:3r, Hby:3r3w, Mrb:3r
3-4-2017	Extratropical Debbie	Nld:3r, Ald:2r, Wko:3r, Bop:1r, Hby:3r, Hor:2r, Wgn:2r, Cny: 3r3w
15-3-2015	Extratropical Cyclone Pam	Gsb:3r
14-3-2014	Extratropical Cyclone Lusi	Nld:3w, Ald:3w, Wko:3r
19-2-2009	Extratropical Cyclone Innis	Ald:3r, Wko:3r, Bop:3r3w, Tki:3r, Wgn:3r, Wst:3r, Cny: 3r, Ota:3r
20-1-2008	Extratropical Cyclone Funa	Hby:3w, Tki:3w, Hor:2w, Wgn:3w
27-2-2004	Extratropical Cyclone Ivy	Nld:3r, Ald:3r 3w, Wko:3r, Bop:3r, Hby:3r, Tki:3r, Hor:2r, Wgn:3r
12-4-2001	Extratropical Cyclone Sose	Nld:1r 3w, Ald:3r, Wko: 3r, Bop:3r, Hor: 3w, Mrb:3w
28-3-1998	Extratropical Cyclone Yali	Wgn:3w3r, Tas:3r, Mrb:3w, Wst:2w3r, Sld:3w3r
11-3-1997	Extratropical Cyclone Gavin	Nld:3r3w, Wko:3w3r, Bop:3w3r, Gsb:3w3r
10-1-1997	Extratropical Cyclone Drena	Nld:3w, Ald:2w, Wko:3w3r, Tki:3w, Tas:3w, Cny: 3w3r, Ota:3r, Sld:2r
28-12-1996	Extratropical Cyclone Fergus	Nld:2r, Ald:2r, Wko:1r3w, Bop:3w, Gsb:3w
31-3-1996	Extratropical Cyclone Beti	Gsb:3r, Hby:3r3w

Source: NIWA and MetService Historical Weather Events (HWE) Catalogue
Indicators: Nld: Northland, Ald: Auckland, Wko: Waikato, Bop: Bay of Plenty, Gsb: Gisborne, Hby: Hawke's Bay, Tki: Taranaki, Wgn: Wellington, Tas: Tasman, Mrb: Marlborough, Wst: West Coast, Cny: Canterbury, Ota: Otago, Sld: Southland, Chi: Christchurch, Hor: Horowhenua.
High likelihood = 1, Moderate likelihood = 2, Low likelihood = 3, r - Rain, w – Wind.

Appendix Table 2.4: Types of Individual Income

Income Type	Description
WAS	The total amount of income received by the individuals for the specified tax year from Wages and Salaries.
WHP	The total amount of income received by the individuals for the specified tax year from withholdings payments.
BEN	The total amount of income received by the individuals for the specified tax year from benefits payments.
ACC	The total amount of income received by the individuals for the specified tax year from ACC payments.
PEN	The total amount of income received by the individuals for the specified tax year from Pension payments.
PPL	The total amount of income received by the individuals for the specified tax year Paid parental leave payments.
STU	The total amount of income received by the individuals for the specified tax year from Student Allowance payments.
C00	The total amount of income received by the individuals for the specified tax year from director/shareholders receiving company income.
C01	The total amount of income received by the individuals for the specified tax year from company director/shareholders paying themselves a wage and salary.
C02	The total amount of income received by the individuals for the specified tax year from company director/shareholders paying themselves withholding payments.
P00	The total amount of income received by the individuals for the specified tax year from partners receiving partnership income.
P01	The total amount of income received by the individuals for the specified tax year from partners paying themselves a wage and salary.
P02	The total amount of income received by the individuals for the specified tax year from partners paying themselves withholding payments.
S00	The total amount of income received by the individuals for the specified tax year from sole traders receiving net profits.
S01	The total amount of income received by the individuals for the specified tax year from sole traders paying themselves a wage and salary.
S02	The total amount of income received by the individuals for the specified tax year from sole traders paying themselves withholding payments.
S03	The total amount of income received by the individuals for the specified tax year from sole traders receiving rental income.

Source: Adapted from Statistics New Zealand's Integrated Data Infrastructure (IDI), (2021)

Appendix Table 2.5: Impact of Extratropical Cyclone on Individual Income (Standardized Coefficients)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	0.00600	0.00150	0.00144	0.00652
	(0.00465	(0.00745)	(0.00617)	(0.00479)
D_{2015}	0.000954	-0.00528	0.00506	0.00242
	(0.00538)	(0.00753)	(0.00608)	(0.00530)
D_{2016}	-0.00512	-0.00436	0.0105	-0.000935
	(0.00585)	(0.00819)	(0.00797)	(0.00602)
$D_{2017}{}^{\dagger}$	-0.0136**	-0.000392	0.0130	-0.00751
	(0.00604)	(0.00791)	(0.00869)	(0.00639)
D_{2018}	-0.00856	0.00398	0.00619	-0.00506
	(0.00615)	(0.00801)	(0.00734)	(0.00624)
D_{2019}	-0.0121	-0.00752	0.0229**	-0.00270
	(0.00744)	(0.00870)	(0.0103)	(0.00772)
R^2 (within)	0.037	0.0002	0.0018	0.039
R^2 (between)	0.0178	0.0011	0.0011	0.0231
Number of individuals	2,379,936	2,379,936	2,379,936	2,379,936
Number of observations	19,332,492	19,332,492	19,332,492	19,332,492

Note: † = Extratropical cyclone-affected meshblocks in 2017.

Regression coefficients are expressed as standardized coefficients; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.6: Impact of Extratropical Cyclone on Above-median Individual Income (Standardized Coefficients)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	0.0049	-0.0119	-0.00136	0.00268
	(0.00683)	(0.00894)	(0.013)	(0.00752)
D_{2015}	0.00201	-0.0157	-0.000449	-0.000153
	(0.00772)	(0.0116)	(0.0114)	(0.00758)
D_{2016}	-0.00443	-0.0106	0.0148	0.000797
	(0.00822)	(0.01)	(0.0131)	(0.00807)
$D_{2017}^{\dagger}$	-0.0127	-0.0112	0.0234*	-0.00352
	(0.00815)	(0.0103)	(0.014)	(0.00833)
D_{2018}	-0.00869	0.00704	0.01	-0.00320
	(0.00816)	(0.0114)	(0.0123)	(0.00804)
D_{2019}	-0.0135	-0.0193	0.0414**	0.00238
	(0.0104)	(0.0131)	(0.0167)	(0.0101)
R^2 (within)	0.094	0.0004	0.0037	0.105
R^2 (between)	0.0123	0.000	0.0007	0.0150
Number of individuals	1,562,673	1,562,673	1,562,673	1,562,673
Number of observations	9,530,400	9,530,400	9,530,400	9,530,400

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed as standardized coefficients; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income (above-median) from the tax year 2010-2019. The median income is calculated from total individual income from the extratropical cyclone-affected meshblocks in 2016. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.7: Impact of Extratropical Cyclone on Below-median Individual Income (Standardized Coefficients)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	0.0011	0.00152	-0.000282	0.00111
	(0.00192)	(0.00874)	(0.00281)	(0.00214)
D_{2015}	-0.00221	-0.00258	-0.00122	-0.00293
	(0.00201)	(0.0101)	(0.00286)	(0.00228)
D_{2016}	0.000845	0.000528	0.000331	0.00101
	(0.00203)	(0.0108)	(0.00289)	(0.00233)
$D_{2017}^{\dagger}$	0.00151	0.00423	0.00324	0.00332
	(0.00204)	(0.0104)	(0.0027)	(0.00231)
D_{2018}	0.00127	-0.000094	0.00197	0.00204
	(0.00197)	(0.0101)	(0.00262)	(0.00226)
D_{2019}	0.000906	-0.00891	0.00372	0.00138
	(0.00209)	(0.0117)	(0.00348)	(0.00258)
R^2 (within)	0.0005	0.0006	0.0005	0.0012
R^2 (between)	0.0155	0.0023	0.0000	0.0246
Number of individuals	1,865,736	1,865,736	1,865,736	1,865,736
Number of observations	9,802,092	9,802,092	9,802,092	9,802,092

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed as standardized coefficients; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income (below-median) from the tax year 2010-2019. The median income is calculated from total individual income from the extratropical cyclone-affected meshblocks in 2016. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.8: Impact of Extratropical Cyclone on Individual Income (Male Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	259.7	92.08	158.8	510.6
	(303.2)	(60.23)	(217.1)	(349.4)
D_{2015}	-102.8	55.97	416.2**	369.4
	(345.1)	(55.69)	(203.2)	(369.0)
D_{2016}	-491.3	-0.812	517.5**	25.41
	(387.7)	(58.05)	(254.5)	(428.1)
$D_{2017}^{\dagger}$	-876.2**	79.85	613.5**	-182.9
	(393.6)	(59.41)	(281.5)	(446.1)
D_{2018}	-780.8**	59.86	342.3	-378.6
	(392.7)	(60.95)	(234.8)	(430.4)
D_{2019}	-1,022**	-63.19	968.1***	-117.4
	(483.7)	(57.72)	(331.6)	(542.5)
R^2 (within)	0.038	0.0003	0.0017	0.039
R^2 (between)	0.0193	0.0077	0.0017	0.0248
Number of individuals	1,167,486	1,167,486	1,167,486	1,167,486
Number of observations	9,536,529	9,536,529	9,536,529	9,536,529

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.9: Impact of Extratropical Cyclone on Individual Income (Female Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	211.0	-68.52	-31.99	110.5
	(226.4)	(47.62)	(92.18)	(224.1)
D_{2015}	189.2	-98.98*	-142.1	-51.85
	(267.1)	(53.32)	(105.5)	(264.0)
D_{2016}	116.8	-56.87	-127.5	-67.52
	(278.5)	(60.32)	(139.8)	(286.1)
$D_{2017}^{\dagger}$	-201.9	-91.91*	-148.1	-442.0
	(296.4)	(55.61)	(145.3)	(314.6)
D_{2018}	139.6	-37.38	-110.4	-8.196
	(313.7)	(53.89)	(129.2)	(317.3)
D_{2019}	59.16	-25.64	-150.2	-116.7
	(363.6)	(67.15)	(174.1)	(372.6)
R^2 (within)	0.039	0.0007	0.0024	0.043
R^2 (between)	0.0201	0.0093	0.0007	0.0268
Number of individuals	1,212,450	1,212,450	1,212,450	1,212,450
Number of observations	9,795,960	9,795,960	9,795,960	9,795,960

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Table 2.10: Impact of Extratropical Cyclone on Individual Income (European Ethnic Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	305.8	23.99	86.78	416.6*
	(223.2)	(44.27)	(148.8)	(250.1)
D_{2015}	261.2	-25.93	154.5	389.8
	(253.2)	(43.14)	(144.3)	(267.0)
D_{2016}	156.3	-62.00	159.5	253.8
	(282.6)	(47.27)	(182.2)	(309.0)
$D_{2017}^{\dagger}$	-513.0*	-40.53	259.8	-293.8
	(294.0)	(46.28)	(199.9)	(331.3)
D_{2018}	-356.8	19.71	142.3	-194.8
	(303.8)	(46.44)	(167.0)	(326.3)
D_{2019}	-454.5	-35.58	482.2**	-7.880
	(367.8)	(51.44)	(237.8)	(404.7)
R^2 (within)	0.028	0.0002	0.002	0.030
R^2 (between)	0.0160	0.0000	0.0008	0.0194
Number of individuals	1,706,877	1,706,877	1,706,877	1,706,877
Number of observations	14,434,296	14,434,296	14,434,296	14,434,296

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.11: Impact of Extratropical Cyclone on Individual Income (Maori Ethnic Group)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	-76.68	-167.7	131.6	-112.8
	(538.3)	(173.3)	(141.5)	(496.6)
D_{2015}	-740.6	-237.1	219.9	-757.8
	(768.2)	(197.7)	(153.3)	(722.6)
D_{2016}	-1,635**	189.9	-60.33	-1,506**
	(766.3)	(221.0)	(192.9)	(738.5)
$D_{2017}^{\dagger}$	-1,359*	125.7	-240.2	-1,474**
	(765.8)	(206.0)	(155.3)	(734.9)
D_{2018}	-1,114	-61.24	42.94	-1,132
	(763.0)	(205.5)	(194.5)	(716.9)
D_{2019}	-1,047	-64.54	288.6	-823.3
	(823.7)	(217.0)	(339.6)	(809.5)
R^2 (within)	0.049	0.001	0.0016	0.059
R^2 (between)	0.0392	0.0159	0.0013	0.0665
Number of individuals	180,894	180,894	180,894	180,894
Number of observations	1,507,440	1,507,440	1,507,440	1,507,440

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.12: Impact of Extratropical Cyclone on Individual Income (Pacific Ethnic Group)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	-73.08	236.0	-92.99	69.98
	(643.9)	(157.0)	(220.5)	(600.0)
D_{2015}	-1,370*	505.2***	-142.8	-1,007
	(798.5)	(193.2)	(213.7)	(756.5)
D_{2016}	-1,004	212.3	-152.4	-944.6
	(843.8)	(189.8)	(198.0)	(789.7)
$D_{2017}^{\dagger}$	-858.5	326.2*	-105.4	-637.7
	(888.5)	(197.1)	(236.3)	(840.3)
D_{2018}	-298.8	141.8	-244.7	-401.8
	(867.0)	(183.8)	(386.2)	(878.0)
D_{2019}	214.6	231.2	-245.4	200.4
	(1,032)	(225.1)	(206.2)	(984.8)
R^2 (within)	0.099	0.002	0.001	0.094
R^2 (between)	0.0515	0.0242	0.0008	0.0778
Number of individuals	116,880	116,880	116,880	116,880
Number of observations	894,624	894,624	894,624	894,624

Note: † = Extratropical cyclone-affected meshblocks in 2017.

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.13: Impact of Extratropical Cyclone on Individual Income (Asian Ethnic Group)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	47.98	-104.4	56.93	0.546
	(559.8)	(81.82)	(213.3)	(563.9)
D_{2015}	-121.0	-57.99	71.15	-107.8
	(633.9)	(91.00)	(251.2)	(651.3)
D_{2016}	-811.5	-29.42	470.3	-370.6
	(648.5)	(91.64)	(315.3)	(678.9)
$D_{2017}^{\dagger}$	109.8	30.50	352.8	493.1
	(642.1)	(82.53)	(368.8)	(689.9)
D_{2018}	283.1	1.654	103.4	388.2
	(650.4)	(94.71)	(339.2)	(691.1)
D_{2019}	-435.0	-134.5	144.1	-425.4
	(797.5)	(87.35)	(369.4)	(823.5)
R^2 (within)	0.116	0.0011	0.004	0.112
R^2 (between)	0.0183	0.0174	0.0020	0.0245
Number of individuals	321,051	321,051	321,051	321,051
Number of observations	2,102,832	2,102,832	2,102,832	2,102,832

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Table 2.14: Impact of Extratropical Cyclone on Individual Income (MELAA Ethnic)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	-1,549	66.74	-484.8	-1,967
	(2,226)	(446.7)	(1,115)	(2,422)
D_{2015}	-2,734	-234.0	217.2	-2,751
	(2,749)	(352.2)	(613.5)	(2,813)
D_{2016}	-3,612	-313.5	2,708	-1,218
	(2,455)	(381.7)	(2,463)	(3,421)
$D_{2017}^{\dagger}$	-2,828	-560.2	-260.0	-3,648
	(2,149)	(518.2)	(830.8)	(2,343)
D_{2018}	3,724**	-356.6	-370.3	2,997*
	(1,896)	(382.9)	(684.6)	(1,806)
D_{2019}	679.7	-387.4	-460.4	-168.0
	(2,019)	(384.5)	(1,232)	(2,205)
R^2 (within)	0.095	0.001	0.006	0.112
R^2 (between)	0.0122	0.0013	0.0023	0.0209
Number of individuals	29,340	29,340	29,340	29,340
Number of observations	184,773	184,773	184,773	184,773

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.15: Impact of Extratropical Cyclone on Individual Income (Non-tertiary Education Certificate Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	-214.7	42.22	111.0	-61.52
	(308.4)	(91.92)	(145.7)	(313.8)
D_{2015}	-137.8	18.66	293.4	174.3
	(344.9)	(115.0)	(225.3)	(367.7)
D_{2016}	-427.5	-194.6*	15.77	-606.4
	(380.8)	(113.0)	(287.0)	(439.5)
$D_{2017}^{\dagger}$	-547.7	9.840	-200.1	-738.0*
	(399.8)	(117.3)	(261.2)	(439.5)
D_{2018}	-263.0	69.99	-148.6	-341.6
	(394.3)	(128.5)	(203.5)	(410.4)
D_{2019}	179.0	-50.45	371.9	500.4
	(432.6)	(122.8)	(313.6)	(497.0)
R^2 (within)	0.003	0.0011	0.0004	0.003
R^2 (between)	0.0112	0.0024	0.0004	0.0161
Number of individuals	381,882	381,882	381,882	381,882
Number of observations	3,376,431	3,376,431	3,376,431	3,376,431

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Table 2.16: Impact of Extratropical Cyclone on Individual Income (Tertiary Education Certificate Group)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
D_{2014}	-7.678	57.24	-19.68	29.88
	(328.6)	(66.29)	(159.3)	(336.5)
D_{2015}	27.07	-53.36	253.5	227.2
	(366.4)	(63.27)	(189.8)	(377.0)
D_{2016}	-637.1	-37.11	273.5	-400.7
	(396.2)	(81.61)	(201.5)	(406.8)
$D_{2017}^{\dagger}$	-440.6	-20.75	236.5	-224.8
	(417.2)	(72.11)	(237.2)	(441.1)
D_{2018}	-122.6	10.47	173.9	61.70
	(429.5)	(71.30)	(169.3)	(430.1)
D_{2019}	-707.3	97.01	-230.9	-841.2
	(493.0)	(94.33)	(268.1)	(534.0)
R^2 (within)	0.039	0.0002	0.002	0.040
R^2 (between)	0.0447	0.0068	0.0021	0.0544
Number of individuals	665,988	665,988	665,988	665,988
Number of observations	5,098,605	5,098,605	5,098,605	5,098,605

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.17: Impact of Extratropical Cyclone on Individual Income (Diploma Degree Qualification Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	1,183	-294.9	-317.8	570.1
	(925.9)	(216.8)	(296.9)	(923.6)
D_{2015}	474.3	-281.9	-497.8	-305.4
	(932.1)	(257.6)	(336.3)	(949.9)
D_{2016}	929.6	-170.5	-809.2**	-50.11
	(1,035)	(282.9)	(346.5)	(1,015)
$D_{2017}^{\dagger}$	-93.61	45.63	-302.9	-350.9
	(990.4)	(267.2)	(627.4)	(1,117)
D_{2018}	-415.6	-94.45	-916.0*	-1,426
	(1,098)	(290.3)	(487.0)	(1,117)
D_{2019}	479.7	-548.1**	-753.2	-821.6
	(1,204)	(236.3)	(492.9)	(1,232)
R^2 (within)	0.046	0.001	0.002	0.054
R^2 (between)	0.0088	0.008	0.0007	0.0161
Number of individuals	75,750	75,750	75,750	75,750
Number of observations	655,707	655,707	655,707	655,707

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Table 2.18: Impact of Extratropical Cyclone on Individual Income (Bachelor Degree Qualification Group)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	-540.3	72.39	205.5	-262.4
	(760.3)	(211.0)	(316.7)	(767.9)
D_{2015}	-115.4	317.7	-489.2	-287.0
	(801.7)	(218.8)	(335.7)	(797.7)
D_{2016}	-1,493	664.7**	-521.8	-1,350
	(899.9)	(263.5)	(421.7)	(949.3)
$D_{2017}^{\dagger}$	-2,186**	632.7**	-419.6	-1,972**
	(909.0)	(278.6)	(506.0)	(977.5)
D_{2018}	-1,211	559.1**	560.4	-91.15
	(929.8)	(252.4)	(591.3)	(1,001)
D_{2019}	-2,590**	210.9	1,369	-1,011
	(1,211)	(288.5)	(1,085)	(1,284)
R^2 (within)	0.075	0.001	0.002	0.087
R^2 (between)	0.0159	0.0069	0.0008	0.0269
Number of individuals	97,440	97,440	97,440	97,440
Number of observations	813,435	813,435	813,435	813,435

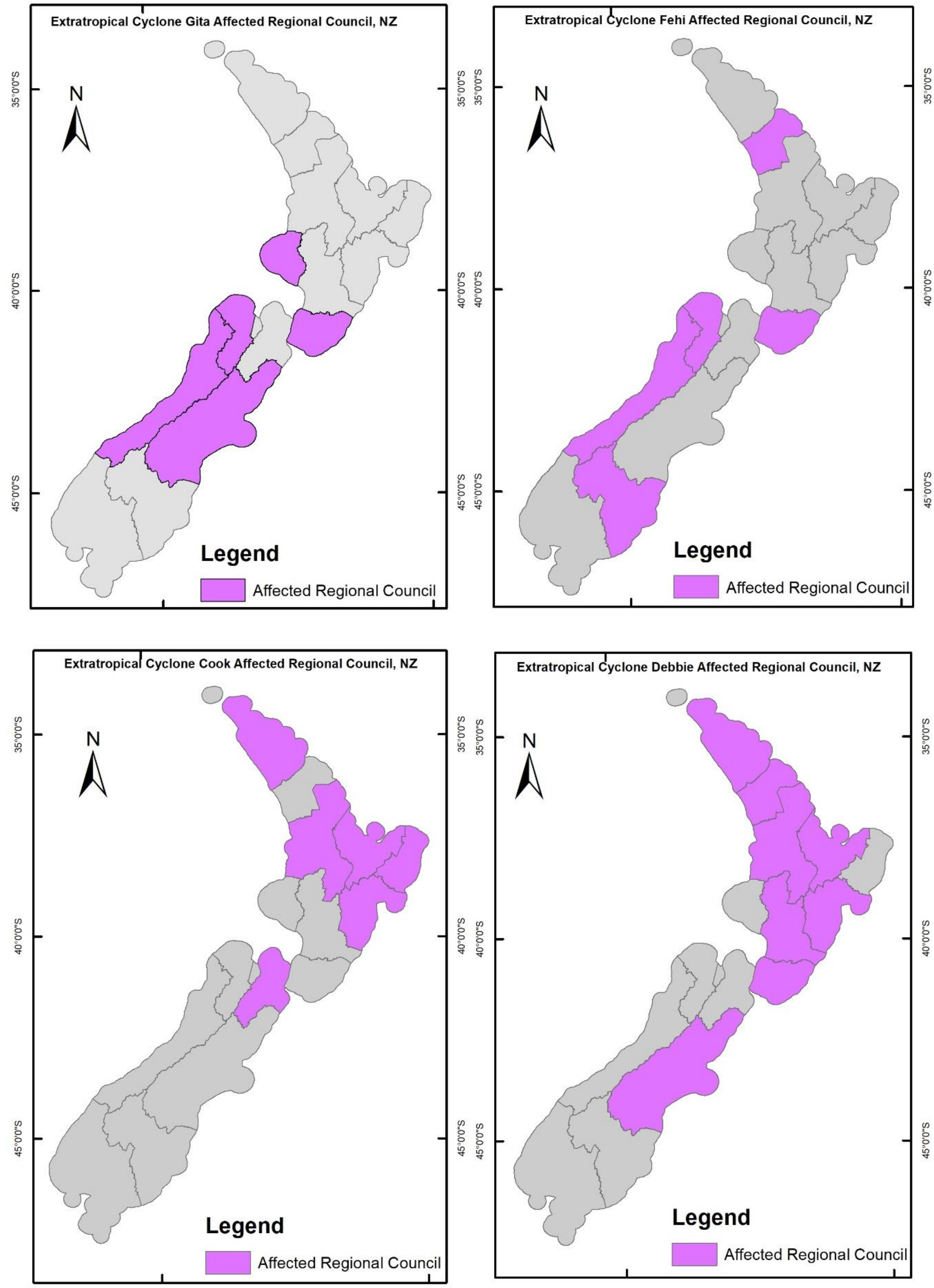
Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Appendix Table 2.19: Impact of Extratropical Cyclone on Individual Income (Post-bachelor Degree Educational Qualification Group)

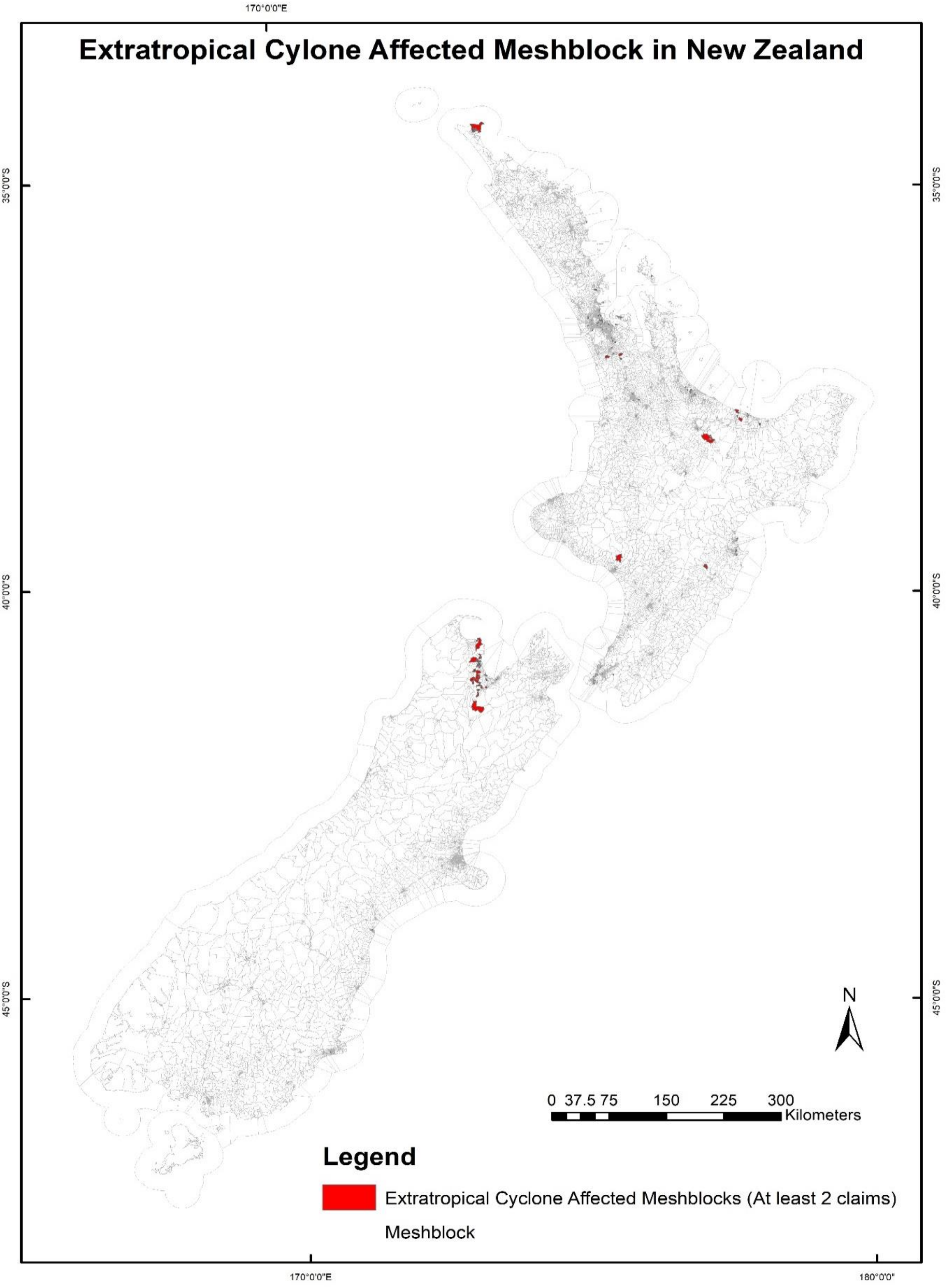
	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
D_{2014}	23.74	47.63	103.7	175.0
	(412.9)	(118.7)	(289.2)	(464.6)
D_{2015}	-193.8	-29.95	387.0	163.3
	(469.0)	(93.45)	(290.6)	(495.0)
D_{2016}	-142.9	69.92	791.8	718.8
	(517.9)	(104.1)	(482.2)	(651.1)
$D_{2017}^{\dagger}$	-47.44	-33.13	930.0*	849.4
	(539.7)	(105.7)	(558.3)	(723.0)
D_{2018}	-391.3	-20.45	482.1	70.42
	(560.5)	(102.0)	(477.0)	(703.9)
D_{2019}	-134.0	-163.3*	951.5	654.2
	(670.2)	(95.50)	(635.0)	(860.3)
R^2 (within)	0.033	0.0001	0.003	0.039
R^2 (between)	0.0061	0.0014	0.0005	0.0086
Number of individuals	425,151	425,151	425,151	425,151
Number of observations	3,769,743	3,769,743	3,769,743	3,769,743

Note: † = Extratropical cyclone-affected meshblocks in 2017.
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. Clustered standard errors (at the individual level) are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Appendix Figure 2.1: Extratropical Cyclone Affected Regional Council in New Zealand

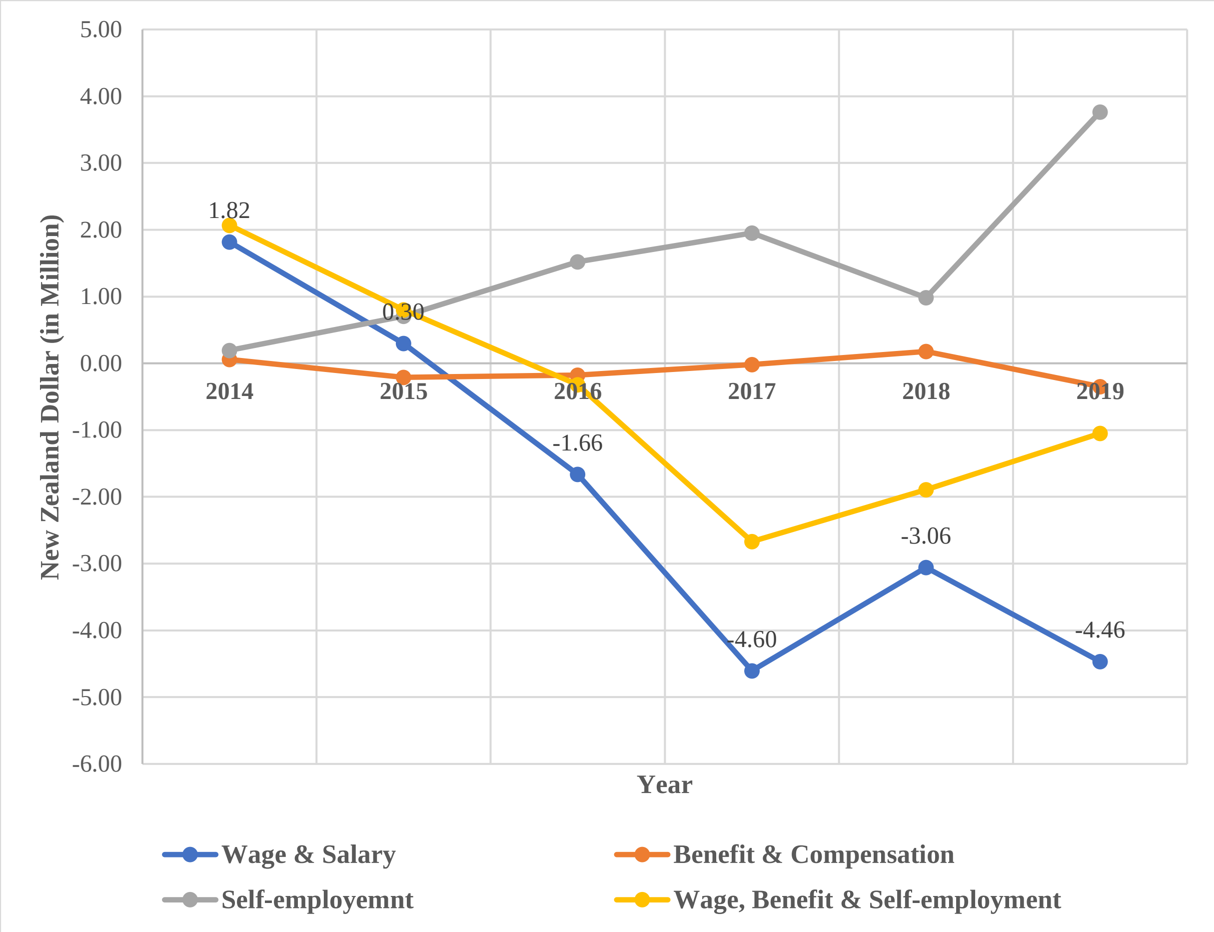


Appendix Figure 2.2: Extratropical Cyclone Affected Meshblock (At Least Two Weather-related Insurance Claims) in New Zealand



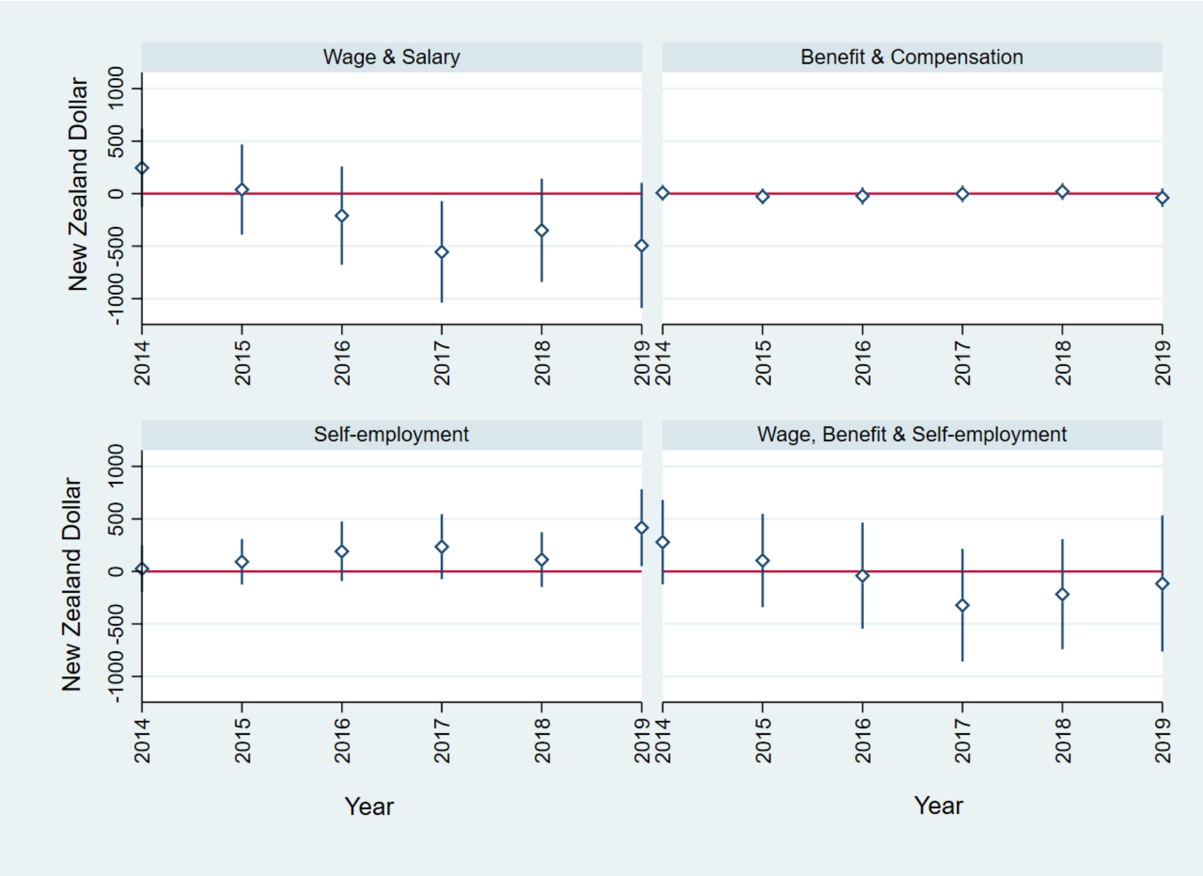
Appendix Figure 2.3: Average Individual Income Distribution in New Zealand

Appendix Figure 2.4: Aggregate Economic Cost of Extratropical Cyclone on Affected Meshblocks in New Zealand



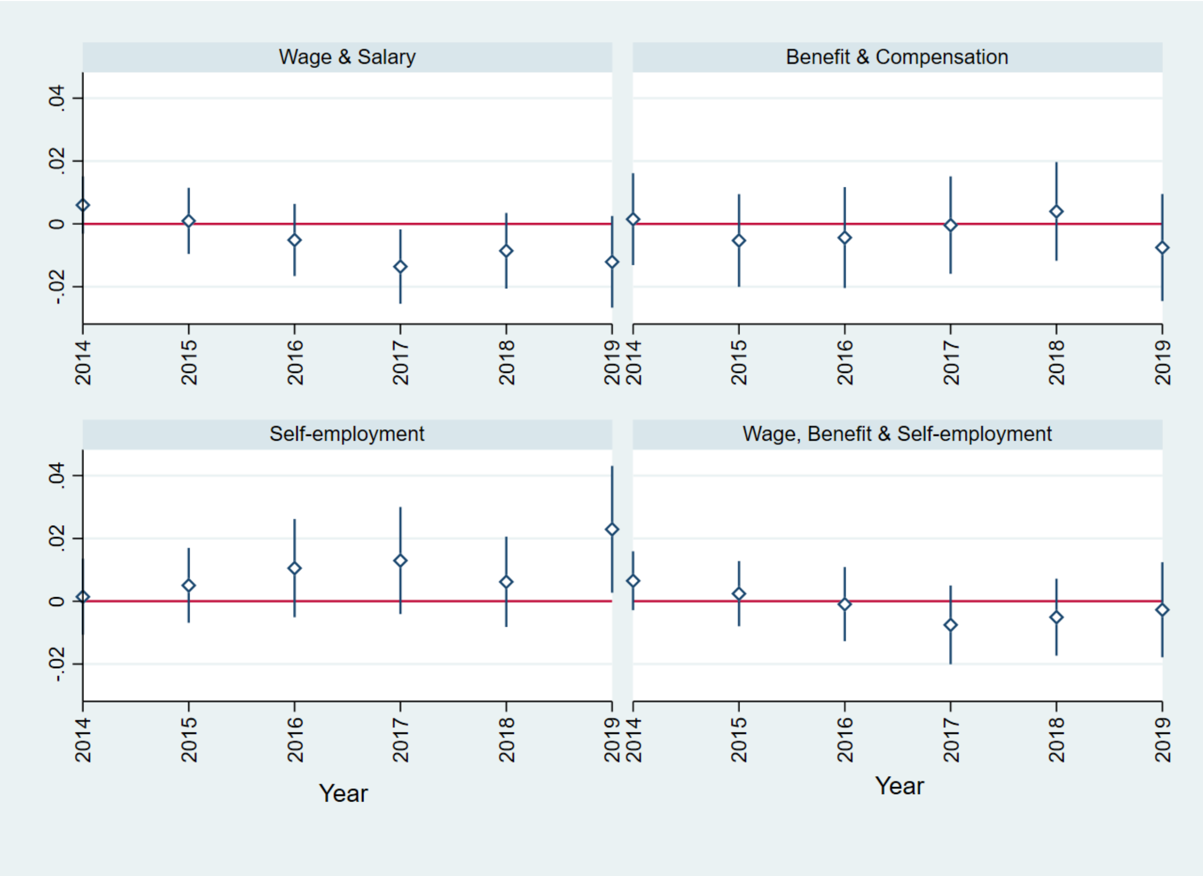
Notes: The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. These figures are the product of regression coefficients and the number of individuals in affected meshblocks in the corresponding year. Every regression is adjusted for individual and year fixed effects. Robust standard errors adjusted for clustering at the individual level.

Appendix Figure 2.5: Impact of Extratropical Cyclone and Individual Incomes (Absolute Coefficient)



Notes: The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. These figures indicate the point estimates of the impact of extratropical cyclones (occurred in 2017) on individual incomes by using the specification in equation (1). Regression coefficients are expressed as New Zealand Dollar. Every regression is adjusted for individual and year fixed effects. Robust standard errors adjusted for clustering at the individual level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 2.6: Impact of Extratropical Cyclone and Individual Incomes (Standardized Coefficient)



Notes: The analysis is conducted based on a panel of individual income from the tax year 2010-2019. The cyclone-affected meshblocks are based on at least two weather-related insurance claims. These figures indicate the point estimates of the impact of extratropical cyclones (occurred in 2017) on individual incomes by using the specification in equation (1). Regression coefficients are expressed as standardized coefficients. Every regression is adjusted for individual and year-fixed effects. Robust standard errors adjusted for clustering at the individual level. 95 percent confidence intervals are shown for each point estimate.

CHAPTER THREE : INCOME AND FLOODS IN NEW ZEALAND

Abstract

Floods include some of the most frequent and costliest extreme weather events in Aotearoa New Zealand. Using data from Statistics New Zealand's Integrated Data Infrastructure and Historical Weather Events Catalogue from the National Institute of Water and Atmospheric Research (NIWA), this study empirically investigates the impact of floods on individual income across the country. The study considered thirteen economically significant flood events and the income of all the Inland Revenue registered individuals between 2000 and 2019. The impact of floods on the affected individual's annual income was assessed using panel regressions with individual and time-fixed effects. Despite the large floods-induced privately insured damages, floods had no significant impact on individual annual incomes from salary, wage, self-employment, and total income across various specifications.

3.1 INTRODUCTION

Aotearoa New Zealand is highly vulnerable and exposed to a range of extreme weather events because of its unique latitudinal range between ∼35°S and ∼47°S (McAneney et al., 2022). Flood is the most common and second costliest insured disaster after earthquakes in New Zealand. The main cause of floods is heavy or prolonged rainfall (NIWA, 2021a). The consequence of floods in New Zealand is potentially catastrophic as almost two-thirds of the country's population resides in flood-prone regions (Royal Society of New Zealand, 2016). Flood damages houses, infrastructure, and farmland causing a substantial economic cost (Stephenson et al., 2018). Insurance Council New Zealand (ICNZ) provides an account of actual insurance claims payment against natural hazards in the country, including floods. Appendix Table 1 briefly discusses the major floods in New Zealand during the last decades.

Flooding events have caused significant property damage and economic loss during the last years in New Zealand. A flood occurred in the Manawatu–Wanganui region in February 2004, causing widespread damage, disruption, and landslips, particularly in rural areas. About 2500 people were displaced during the flood, and the total flood-related cost was estimated at almost NZD 300 million (Fuller & Heerdegen, 2005). A case study using a household survey indicated that 29 percent of the surveyed households reported themselves as flood-affected after the flood in 2004 at the Hutt Valley of Wellington Region in the lower North Island of New Zealand. About 6.9 percent of households were financially worse off (Quade & Lawrence, 2011). Craig et al. (2021) quantified agricultural land exposed to flood hazards, identified the flood hazard zone for agricultural land, and reported that 1.50 million hectares of land were exposed to flood, including 0.417 million hectares in dairy farming in 2016. The study also concludes that dairy farming is less resilient to flood impacts than other sectors. Paulik et al. (2021) conducted farm-level research that shows that dairy farms located at Edgecumbe in the Bay of Plenty were adversely affected by a flood in 2017. The floods caused direct and indirect damage to farms' capital and assets and disrupted daily operations.

Floods are responsible for substantial negative impacts on household income, expenditure, consumption, and employment across the countries. A flood event in South Carolina, United States, caused a USD 1,324 loss in productivity per household because of workplace closure (Gall et al., 2022). In Germany, floods negatively shocked the income level of high- and low-income households (Osberghaus, 2021). The wage earning of flood-affected individuals in

Ireland decreased by up to 39 percent depending on the extent of flood impacts in the worst affected area. The 2011 Bangkok flood led to a decline in flood-affected households' business and agricultural income (Noy et al., 2021). Besides, the annual household expenditure level decreased significantly (Nabangchang et al., 2015; Poaponsakorn et al., 2015). The 2017 flood-affected rural households in Bangladesh experienced a decline in consumption during the post-flood time (Mondal et al., 2021). The daily labour employment of ten million rural households was severely disrupted due to the great 1998 floods (Del Ninno, 2001). The flood-affected households in Ecuador, India, and Pakistan also experienced a decline in consumption levels after the food event (Abbas et al., 2018; Patnaik & Narayanan, 2015; Rosales-Rueda, 2018).

We investigate the impact of floods on individual income by utilizing the longitudinal panel data available at Statistics NZ’s Integrated Data Infrastructure (IDI). We consider this study the first attempt to investigate floods' impacts on individual income in New Zealand as we are not aware of any such research in the existing literature. The study’s research question examines the impact of floods on different types of income, such as earning from wage and salary, benefit and compensation, and self-employment income in New Zealand. We also investigate the effect of the floods across various socio-demographic groups.

The paper's remaining sections are organized as follows: Section 2 briefly describes relevant literature on floods and their impacts on income, consumption/expenditure, and employment at the household level. In Section 3, data and empirical estimation strategies are explained. The result and discussion are presented in Section 4, and Section 5 covers concluding remarks.

3.2 LITERATURE REVIEW

The existing literature on natural disaster impacts primarily focused on the aggregate assessment, including macroeconomic indicators such as Gross Domestic Production (GDP) at the cross-country level (Felbermayr & Gröschl, 2014; Hsiang & Jina, 2014; Lee & Zhang, 2022; Noy, 2009; Strobl, 2012). The short-term impact of natural disasters on economic growth is reported to be negative. However, the long-term effects remain inconclusive (Cavallo & Noy, 2011; Lazzaroni & van Bergeijk, 2014). These country-level studies provide limited insights into the country's heterogeneity and distributional impacts. Besides, macroeconomic indicators often overlook the changes in overall social well-being after a disaster since these indicators represent economic activity other than welfare. Similarly, national-level studies can also be less beneficial for disaster management policy implications because disasters usually hit local areas (Allaire, 2018). Thus, the welfare impacts can be better realized using microeconomic indicators, including individual/household income, consumption, and saving, instead of macroeconomic indicators.

Several studies have investigated the impacts of disasters, including floods, at the household level in recent years. Using a face-to-face household survey, Nabangchang et al. (2015) assessed the economic cost of a more significant Thailand flood in 2011. The study found that households affected by the flood had a median economic loss of USD 3089, which amounted to almost half of the annual household expenditure. The middle-income households incurred a higher economic loss than the poor households because of having valuable property at higher flood risk. Noy et al. (2021) estimated the economic impacts of the 2011 flood on households using rich panel data from the Thai Household Socio-Economic Survey (THSES). The study findings also indicated that the negative effects of the flood on the self-reported directly flood-affected households were driven by the decline in business income in relation to flood-unaffected households. The households not directly affected by the flood but remained near the flooded areas also faced negative shocks on income from business and wages. There is also an indication that higher-wealth households mostly faced a decline in business income, whereas income from agriculture declined for the households with a lower level of wealth. Osberghaus (2021) attempted to assess the impact of flood risk on household income using a detailed household-level survey from the Eval-MAP panel survey (2012 and 2014) in Germany. The study showed that low-income households faced lower monetary flood-induced loss than higher-income households. However, higher-income households had less welfare effects than low-income households because higher-income households had the larger financial resources to mitigate the flood effects. Another household-level study indicates that floods had a negative impact on the subjective well-being of the residents living in the flood-prone areas in France. The cost of mitigating the adverse effects required an immediate compensation of €150,000 per household (Hudson et al., 2019).

Kilgarriff et al. (2019) estimated the impact of flooding disruption on the commuter’s income to understand how the flooding-imposed disruptions and cost on the road network in Galway County of the Republic of Ireland during the 2016 Flood event. Using the Place of Work School Census of Anonymised Records (POWSCAR) and a nationally representative microdata set, Survey on Income and Living Conditions (SILC), the study identified that disruptions caused by the flood had cost a sizable portion of the wage earnings (up to 39 percent in the worst affected areas) of the individuals in that period. The study also found that low-income people were the most vulnerable due to floods. Gall et al. (2022) assessed the economic impact of school closure due 2015 flash flood on affected households in Richland County and the City of Columbia, South Carolina, USA. Using the online survey of 208 flood-affected households, the study results show, on average, a total of USD 1,324 in lost productivity at the household level and USD 906 in lost productivity for the individual respondent due to workplace closure caused by the flood. Sun et al. (2022) assessed the impact of major and minor floods on business employment and the number of establishments in different economic sectors by using the nationwide county-level panel data from 1992 to 2012 in the United States. They examined a positive but small relationship between minor floods and overall local business activity especially in service sectors. However, they also found that the floods had a negative short-run impact on the agricultural sector.

Poaponsakorn et al. (2015) estimated the impact of the 2011 Thailand flood on household expenditure using a difference-in-difference technique. The findings concluded that flood-affected households experienced a negative shock in the expenditure level during the flood in 2011. The flood caused a decline in the total household expenditure from 5.7% to 14%. The negative impact was larger for the upper- or middle-income group households than for the lower-income group. In another study, Mondal et al. (2021) reported that rural landless households experienced a decline in consumption during the post-flood period after a riverine flood in 2017 at the bank of the Teesta River in Bangladesh. Several studies conducted in flood-affected rural areas in Ecuador, India, Pakistan provide sufficient evidence that to cope with after-flood economic consequences, and affected households were forced to decrease the consumption level in comparison of pre-flood consumption level (Abbas et al., 2018; Patnaik & Narayanan, 2015; Rosales-Rueda, 2018).

Floods have severe effects on the employment of flood-affected communities. Several studies indicate that local-level employment decreased after floods, leaving a large number of households to deal with employment disruption (Ajiboye & Orebiyi, 2021; Buchholz, 2021; Del Ninno, 2001; Sarmiento, 2007). Using three-round panel data, Del Ninno et al. (2003) identified that the 1998 great flood in Bangladesh caused significant disruption to the employment of tens of millions of households, especially for the daily labours in the rural areas. Uncertainty and scarcity of local employment force the people to seek employment opportunities in other parts of the country. A recent study by Bernzen et al. (2019) found that about 6.5 percent of the rural coastal people in Bangladesh migrated to in-land, and one-third of them are the victims of flood events. Floods negatively affect local employment in rural and urban areas (Chen et al., 2013).

3.3 METHODOLOGY

3.3.1 Data Source and Type

Our primary data source is the individual annual income data from various sources available at Integrated Data Infrastructure (IDI), collected and maintained by Statistics New Zealand. The IDI database contains the income information of all the tax-paying individuals. The income data are linked with other data recorded by the IDI using a unique identification code. The time frame of our data covers tax years 2000 (April 2000-March 2001) to 2019 (April 2019-March 2020).

3.3.2 Flood Identification Strategy

The Insurance Council of New Zealand (ICNZ), a representative body of the general insurance industry, publishes a list of disasters in New Zealand since 1968, along with the private sector insurance claims payment due to damages resulting from these disasters (ICNZ, 2021; McAneney et al., 2022). We tracked the flood events from the list spanning twenty years from January 2000 to December 2019 and identified 54 flood events. Among the flood events, we identify the financially significant 16 flood events by considering a threshold of insurance loss of at least NZD 10 million and more from each flood (inflation-adjusted to 2017). Finally, we consider 13 flood events from the list and discard two flood events in 2018-2019 and one flood event in 2000 (Appendix Table 3.1). The reason for omitting the 2018 flood is the absence of flood-affected locations in the Historic Weather Events Catalogue (HWE) and dropping the 2019 flood event is to ensure our flood impact analysis year does not include COVID-19-infected years across the country. Besides, we skipped the 2000 flood event due to a lack of income data before 2000 at the Integrated Data Infrastructure (IDI).

After selecting the 13 flood events, we identify the flood-affected area using the New Zealand Historic Weather Events Catalogue (HWE) collected by the National Institute of Water and Atmospheric Research (NIWA). The HWE is publicly available online, providing a record of major weather events (the time, place, geographic coordinates, and damages or causalities), including for floods (NIWA, 2021b). We identify flood-affected areas with the help of the geographic coordinates provided in HWE and locate 60 flood-affected meshblocks[2] across the

[2] A meshblock is the smallest geographic unit for which statistical data is collected and processed by Statistics New Zealand.

country (Appendix Figure 3.1). A brief description of the flood-affected areas where the meshblocks are located, and the flood's impact is given in Appendix Table 3.1.

3.3.3 Individual Income Data (IDI, Statistics New Zealand)

The study utilizes the annual individual-level income data from the Inland Revenue (IR) available in the IDI of Stats NZ. The income data compiled from various sources are reported in the IR by the taxpayer or employer of the taxpayer during the tax year. The IR guidelines require submitting an income tax return for every individual earning more than NZD 200 within the tax year. Along with the income information, the residential address of the tax filler individuals is also recorded at the meshblock-level to protect the privacy and keep anonymity. Using the geographic coordinates provided in the HWE of NIWA, we matched the coordinates with the meshblock location coordinate at the IDI database. We then identify individual income from flood-affected meshblocks and for individuals from the all the other meshblocks.

We classified income into four broad groups depending on the types of income.

1. Wage & Salary: This income category is the sum of all the annual income from salary and wages (WAS).
2. Benefit & Compensation: Under this classification, financial compensation from the Accident Compensation Commission (ACC) for personal injuries and economic benefits (BEN) from the Ministry of Social Development are summed.
3. Self-employment: Incomes from sole-tradership in the form of net profits (S00), wage and salary (S01), withholding payments (S02), and rental income (S03).
4. Wage, Benefit & Self-employment: This category is the summation of the above three income types.

3.3.4 Estimation Methods

Our estimation approach begins with the assumption that heterogenous time-invariant factors such as gender, education, ethnicity, and other personal characteristics profoundly influence individual income. We also assume that any time-varying effects, especially those related to overall economic variation, might affect the individual income. Hence, we include both individual fixed-effects and time fixed effects in our estimation method by formulating the following equation:

$$Y_{it}^{d} = \beta_1 Flood_{it-2} + \beta_2 Flood_{it-1} + \beta_3 Flood_{it} + \beta_4 Flood_{it+1} + \beta_5 Flood_{it+2} + \lambda_t + \mu_i + \varepsilon_{it} \qquad (1)$$

Here, Y_{it}^{d} refers to income earned by individual *i*, at time *t* in income category *d* such as salary, wage, and self-employment. Here, the flood-affected meshblocks are denoted by $Flood_{it}$, while β_{1-5} denotes coefficients of income of the individuals who lived in the flood-affected area before and after the flood. For example, $Flood_{it}$ =1 for individuals residing in the flood-affected meshblocks and $Flood_{it+1}$ = 1 for the same individuals observed the following year immediately. Similarly, $Flood_{it-1}$ = 1 for the flood-affected individuals observed in one lag year. The year fixed effects (from 2000 to 2019) and individual fixed effects are captured by λ_t and μ_i, respectively. ε_{it} indicates an idiosyncratic error term (ε_{it}~i.i.d). The standard errors are clustered at the individual level to adjust for heteroskedasticity and correlation within the individual over time (Stock & Watson, 2020). The regression model considers only two periods after floods: (t+1) and (t+2). Initially, we estimated also (t+3) with (t+1) and (t+2) for all regression specifications, but found no statistically significant results. Hence, (t+3) was dropped from the final model.

The raw individual-level annual income data from Statistics New Zealand includes many individuals with zero income from all income categories (wage and salary, benefit and compensation, and self-employment), before and after the flood. These individuals may have already left the country, died, did not work or receive benefits, or did not declare their income. To create an appropriate sample, we dropped the individuals having zero income in all income categories before and after floods from our final regression model. However, since a flood-affected individual might experience zero income after floods, dropping the individuals with all zero income from the sample after the flood would understate the flood impacts on individual income. Therefore, we also estimated the same regressions with another sample which did include all individuals with zero income and presented the estimated regressions in the appendix.

3.4 RESULTS AND DISCUSSION

3.4.1 Summary Statistics

Table 3.1 presents the summary statistics of different individual incomes of flood-affected and control individuals, including one year before and after the flood scenario. Column 2 indicates the average income of the individual in the flood year. At the same time, Columns 1 and 3 show the average income of the same group just before and after the flood year, respectively. We also show the average income of the control individuals in Column 4. Average wage and salary from the flood-affected areas indicate a slight increased one year after the floods. We also observe a similar trend for the average income from wage, benefit & self-employment. However, the volume of average income from benefit and consumption was the lowest following self-employment income.

3.4.2 Estimation Results

This section presents the results from the estimated impact of floods on the incomes of individuals living in flood-affected areas compared with non-affected regions. We show regression results for the above and below-median income and various sociodemographic groups. In addition, we also show the standardized regression coefficients (measured using zero mean and one standard deviation) presented in the Appendix. We use the standardized regression coefficients to understand the strength of explanatory variables on the explained variable. We estimate the regression equation after dropping 19 percent or 5,367,795 observations having zero value in all income categories (wage and salary, benefit and compensation, and self-employment) from the total observations. The reason is that the individuals with zero values in all income categories may not be affected by floods in any possible ways. There might be a proportion of people in the dataset who do not work or are voluntarily avoid working, and floods have no ability to affect their incomes. Hence, we drop these observations.

3.4.3 Flood Impact on Individual Income

Table 3.2 shows the estimated regression results on the impact of floods on the individual in the flood-affected areas following Equation 1. The estimated coefficients presented in Column 1 show that the dummy variable ($Flood_{it}$) is statistically insignificant and negative. It indicates that after controlling for time-invariant fixed effects, there is no significant difference in individual income from wage and salary from the flood-affected areas compared with the flood-unaffected areas. The estimated coefficients of dummy variables $Flood_{it+1}$ and $Flood_{it+2}$ are also found statistically insignificant, indicating no statistical evidence of flood impact on wage and salary income aftermath the two consecutive years of the flood year. The estimated income coefficients from benefit and compensation (Column 2) and self-employment (Column 3) were statistically insignificant, implying no evidence of flood impact on these income types. We also found that the income from wage, benefit & self-employment (Column 4) during the flood year was statistically insignificant.

These results are surprising in the sense that the damage and loss caused by the floods should have a negative impact on the income flow of the individuals in the flood-affected area. However, the negative sign of the coefficient of $Flood_{it}$ indicates the possibility of the adverse effect of floods on the wage and salary income of the flooded-affected people in the flood year.

We also estimated the standardized regression equation using Z-score and presented it in Appendix Table 3.2. The estimated coefficient ($Flood_{it}$) in Column 1 is also negative and statistically insignificant. It indicates that flood-affected individuals experienced no changes in income from wage and salary compared with non-affected individuals. The income coefficients from benefit and compensation (Column 2) and self-employment (Column 3), and wage, benefit & self-employment (Column 4) were all statistically insignificant as well. The result is consistent with the regression result from the absolute value.

Table 3.1: Summary Statistics of Individual Income

	Flooded Individual			**Control Individuals**
	Before Floods (1)	**During Floods (2)**	**After Floods (3)**	**During Floods (4)**
Mean	33,447.05	33,279.70	36,017.98	32,425.27
Std. Dev.	41,502.84	39,686.25	40,750.27	37,844.13
Observations	1,026	1,092	1,050	28,417,035
Mean	2,057.79	2,054.21	2,080.35	2,017.44
Std. Dev.	5,011.855	5,715.871	5,497.892	5,251.671

Observations	1,026	1,092	1,050	28,417,035

Mean	2,117.73	2,225.33	2,842.62	2,394.30
Std. Dev.	17,504.99	14,339.54	17,518.86	18,315.12
Observations	1,026	1,092	1,050	28,417,035

Mean	37,622.57	37,559.24	40,940.94	36,837.01
Std. Dev.	42,563.32	39,868.51	41,653.1	39,416.34
Observations	1,026	1,092	1,050	28,417,035

Note: Income figures are measured in New Zealand Dollars.

Table 3.2: Flood Effects on Individual Income

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	337.1	-99.05	-420.6	-182.5
	(802.0)	(112.9)	(496.1)	(888.9)
$Flood_{it-1}$	548.6	33.75	-475.7	106.7
	(879.0)	(114.2)	(516.7)	(971.2)
$Flood_{it}$	-56.82	55.33	-601.7	-603.2
	(844.1)	(133.5)	(441.7)	(905.9)
$Flood_{it+1}$	684.3	11.81	90.83	786.9
	(855.4)	(123.4)	(373.7)	(881.9)
$Flood_{it+2}$	626.0	17.71	-413.4	230.3
	(827.1)	(113.5)	(499.8)	(909.5)
R^2 (within)	0.142	0.004	0.003	0.149
R^2 (between)	0.006	0.018	0.002	0.013
Number of individuals	2,304,690	2,304,690	2,304,690	2,304,690
Number of observations	28,418,127	28,418,127	28,418,127	28,418,127

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

3.4.4 Impact of Floods on Above-Median and Below-Median Individual Income

We next examine the impact of the floods on individuals whose income is above-median and below-median. The median income is stratified based on income prior flood. Tables 3.3 and 3.4 present the estimated regression coefficients for above-median and below-median income groups, respectively. We also show the standardized regression for the groups stated in Appendix.

From Table 3.3, we observe that the estimated coefficient of $Flood_{it}$ shown in Column 1 is negative and statistically insignificant. It indicates that after adjusting for time-invariant characteristics, on average, individuals in the above-median income group from flood-affected areas faced no changes in income from wage and salary compared with those in flood-unaffected regions. We also notice a negative but statistically insignificant income coefficient from the same individuals' wage, benefit & self-employment income (Column 4). Besides, we observed no statistical changes in income coefficients from the remaining income categories. The results are consistent with the standardized regression coefficients in Appendix Table 3.3.

Table 3.3: Flood Effects on Above-median Income at Individual level

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	-507.7	-114.8	19,044**	177.7
	(1,155)	(736.4)	(9,310)	(1,169)
$Flood_{it-1}$	312.0	83.32	7,313	356.5
	(1,256)	(671.9)	(20,758)	(1,405)
$Flood_{it}$	-54.65	1,572	-7,279	-545.4
	(1,176)	(2,075)	(9,156)	(1,214)
$Flood_{it+1}$	-691.2	-1.564	-4,590	-760.5
	(1,243)	(635.2)	(10,049)	(1,292)
$Flood_{it+2}$	-685.6	466.9	-8,164	-1,073
	(1,109)	(546.4)	(10,433)	(1,224)
R^2 (within)	0.261	0.047	0.038	0.202
R^2 (between)	0.009	0.0008	0.0002	0.011

Number of individuals	1,504,254	27,831	181,623	1,601,640
Number of observations	12,782,130	89,019	734,010	13,820,907

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses. ** p<0.05, ***p < 0.01.

Table 3.4: Flood Effects on Below-median Income at Individual level

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	3.754	-14.08	59.87	68.38
	(379.7)	(99.87)	(118.1)	(414.6)
$Flood_{it-1}$	-95.54	121.3	-20.34	-65.08
	(385.1)	(102.1)	(108.8)	(400.3)
$Flood_{it}$	-42.41	-14.80	-153.8	-67.14
	(377.8)	(98.71)	(106.3)	(403.9)
$Flood_{it+1}$	408.5	16.38	-72.27	273.5
	(390.5)	(101.0)	(108.3)	(402.2)
$Flood_{it+2}$	-4.990	48.70	-28.11	201.2
	(375.6)	(100.3)	(96.91)	(379.7)
R^2 (within)	0.008	0.004	0.001	0.023
R^2 (between)	0.042	0.017	0.001	0.050
Number of individuals	2,130,138	2,304,150	2,298,975	2,107,191
Number of observations	15,635,775	28,329,105	27,684,108	14,597,004

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses.

We also investigated the flood impact for the below-median income group and presented the estimated results in Table 3.4. Results from Table 3.4 indicated that income coefficients from wage and salary (Column 1), benefit and compensation (Column 2), self-employment (Column 3), and wage, benefit & self-employment (Column 4) are statistically significant. It implies no statistical evidence of changes in income before and after the flood events for the below-median income group. The standardized regression reported in Appendix Table 3.4 provides similar results.

3.4.5 Income Effects of Flood Across Different Groups

Flood impacts may vary across other factors, including gender and education. This segment shows the estimated effect of floods on individual income across various sociodemographic groups. More specially, we analysed the income effects of the flood on males, females and individuals based on higher educational qualifications. Our distinction between the different groups is based on the data classification used in the Census 2018. We highlight the estimated results for a selected group in Table 3.5, while the additional detailed analysis is provided in the Appendix.

Table 3.5: Flood Effects on Income of Selected Individual Groups

	Male		**Female**		**Bachelor and Above Certificate Group**	
	Wage & Salary (1)	**Self-employment (2)**	**Wage & Salary (3)**	**Self-employment (4)**	**Wage & Salary (5)**	**Self-employment (6)**
$Flood_{it-2}$	992.1	-567.8	-375.9	-262.7	-1,106	-1,177
	(1,197)	(846.9)	(1,060)	(488.3)	(2,346)	(1,746)
$Flood_{it-1}$	752.8	-471.0	291.7	-478.3**	36.76	-846.1
	(1,281)	(979.6)	(1,202)	(229.4)	(2,697)	(1,465)
$Flood_{it}$	-572.6	-1,019	429.4	-165.7	-949.7	-1,156
	(1,294)	(774.0)	(1,071)	(399.9)	(2,542)	(1,566)
$Flood_{it+1}$	-79.56	28.39	1,422	149.3	832.4	911.0
	(1,277)	(695.2)	(1,135)	(237.6)	(2,541)	(1,194)
$Flood_{it+2}$	-449.8	-411.4	1,657	-424.7	-544.9	-762.3
	(1,175)	(941.2)	(1,171)	(299.3)	(2,460)	(1,801)

R^2 (within)	0.144	0.003	0.150	0.005	0.197	0.006
R^2 (between)	0.009	0.005	0.005	0.001	0.004	0.003
Number of individuals	1,139,169	1,139,169	1,165,518	1,165,518	566,838	566,838
Number of observations	14,011,209	14,011,209	14,406,918	14,406,918	7,268,907	7,268,907

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses. ** p<0.05, ***p < 0.01.

Gender

We analysed the flood impact on male and female income. From Table 3.5, we observe that male income coefficients of wage and salary (Column 1) and self-employment (Column 2) are statistically insignificant. Estimated coefficients of the remaining income categories presented in Appendix Table 3.5 are also statistically insignificant. Although income coefficients from wage and salary are statistically insignificant, it shows that wage and salary of the male group declined by NZD 572.6 during the flood year, by NZD 79.56 after one year, and by NZD 449.8 after the second year.

We also observe a similar result for the female group (Columns 3 and 4). The estimated results presented in Appendix Table 3.6 show that the coefficients of wage and salary (Column 1) from the flood-affected female group are statistically insignificant. It indicates that floods have no impact on income from wage and salary earned by the female group in the flood-affected areas. We also found no statistical change in income from benefits and compensation and self-employment of the female group before and after the floods (Appendix Table 3.6).

Education

We further investigate the impact of the floods on income from different groups based on the highest educational qualification achieved. Based on the criteria used by the Ministry of Education, we classified the individual group into five groups. Group one: Individuals having no tertiary education fall under the non-tertiary qualification group. Group two: Individuals with education qualifications from level 1 to 4 fall under the secondary education certificates group. Group three: The education qualifications level 5 to 8 is considered a tertiary education group. Group four: The diploma degree group completed from levels 9 to 10. Group five:

From education qualifications level 11 to 14, they fall under the bachelor and post-bachelor degree education group. We have dropped groups three and four because of a low number of observations, arbitrarily less than 200 observations from each group.

Table 3.5 indicates the estimated coefficients from wage and salary (Column 5) and benefits and compensation (Column 6) from group five, the bachelor and post-bachelor degree education group. The estimated coefficients again show no statistically significant change in wage and salary income before and after the flood year (Column 5). Besides, income coefficients from self-employment (Column 6) also indicate no flood effects. The detailed estimated regression results for the different educational groups are presented in Appendix Table 3.7-3.9. We found that coefficients from all categories are statistically insignificant for all three educational groups. The estimated income coefficients provide evidence that floods have no statistically significant impact on the incomes earned by individuals from secondary, bachelor's and post-bachelor, and non-tertiary educational degree qualification groups.

3.4.6 Robustness of the Results

In this segment, we attempted to estimate the impact of floods on individual incomes without dropping the observations having zero values. The reason is that there might be some cases where flood-affected individuals' income is reported as zero before and after floods in the Inland Revenue (IR) records. For instance, if an individual's income is affected by a flood just after the registration to Inland Revenue (IR) for the first time, the individual would have zero income before and after the flood event. Dropping that particular type of observation might not explain the impact of the flood on individual income. Hence, we estimate the regression, including all the observations, to check the robustness of our earlier findings. The regression specification used in the main text is more relevant than the other specifications, including the current approach. We keep estimated results from both specifications to ensure the robustness of our findings.

Hence, we show the estimated results from the first approach in the main text and mention the estimated results from the second approach in Appendix Table 3.10-3.21. Appendix Table 3.10 presents the summary statistics. Results from the estimated regression shown in Appendix Table 3.11-3.21 are consistent with our initial results in every specification. We also observe that not all individuals have income from all income categories in a single year. We assume that zero income from each income category might influence the estimated outputs. We drop zero values from each income category and estimate all regression equations. The estimated outputs are consistent with the above-mentioned approaches and hence are not reported in the paper. The consistency with results from both approaches provides additional robustness to our findings presented in the main text.

3.5 CONCLUSION

Flood is one of the most frequent and costly extreme weather events in New Zealand. This study uses the longitudinal panel data from Integrated Data Infrastructure at Statistics New Zealand and Historical Weather Events from NIWA to investigate the impact of floods on individual income in New Zealand. We identify thirteen economically significant flood events that occurred from 2000 to 2019. We also use annual individual income data from 2000 to 2019 to carry out the study by applying individual and time fixed effects panel regression for various specifications. We identified the flood-affected areas at the meshblock level to analyse the flood effects on individual income at the micro-level.

The results show that, on average, floods had no significant impact on the wage and salary, and total income of the individuals residing in flood-affected areas. We also found that incomes from the above-median and below-median income groups experienced no significant negative shock after floods. In addition, we observed no significant impacts of floods on individuals from different individual groups based on gender, ethnicity, and educational qualification. Although the floods were responsible for a great amount of damage to the economy and society, the strong performance and quick economic recovery might reduce (or even eliminate) the immediate impact of floods on individual annual incomes. The study findings provide an in-depth analysis and micro-level investigation regarding the flood impacts on individual income in New Zealand.

APPENDIX

Appendix Table 3.1: A Brief Description of the Floods in New Zealand

Flood Year	Flood Description
2017	*Upper North Island flooding* During March 7-13, 2017, a week-long heavy rain resulted in severe flooding in many parts of the North Island. The worst flood-affected areas were the Coromandel Peninsula and Kaiaua at Waikato, New Lynn, Hunua Ranges, and Clevedon from Auckland, Kerikeri and Kaitaia from Northland. Sever floods cut off the access to the entire Coromandel Peninsula, and houses in Kaiaua were flooded with water. In New Lynn, floodwater swept through 200 homes and caused extensive damage to homes, infrastructures, and businesses. Besides, residents in Clevedon reported huge stock and power losses. Total insurance claims reached NZD 61.7 million. *South Island flooding* Heavy rain and gales from low-pressure systems caused severe flooding in the South and North Islands, especially in the Otago and Canterbury regions, from July 20-22, 2017. Severely flood-affected areas were Dunedin city, Canterbury, Timaru, and Christchurch. Homes were flooded, and low-lying communities were advised to evacuate from Canterbury. A state of emergency was declared in Timaru and Christchurch cities due to the flood. A total of NZD 31.2 million was paid for insurance claims.
2016	*Flooding and Wind - North and South Islands* An extreme weather event brought a flood to the West Coast and Tasman-Nelson regions from March 23-24, 2016. The flood mainly occurred at Franz Josef of the West Coast and Motueka and Riwaka of the Tasman-Nelson regions. A state of emergency was declared in Franz Josef due to extreme flooding. There was excessive flooding in Motueka and Riwaka, so people were evacuated from the severely flooded area. The cost of insurance claims reached NZD 30.2 million.
2015	*Flooding and Storm – Otago* On June 2-4, 2015, a low-pressure system brought heavy rainfall to the southeast of the South Island and caused severe flooding. The worst flood-

	affected areas were Dunedin City and Otago. In addition, parts of rural Nelson were also flooded. Excessive rainfall caused a one in hundred-year flood level in Dunedin, and parts of Dunedin city were badly affected by the flood. Homes were flooded, and people were evacuated. Floodwater also entered the properties in Nelson and Cable Bay. The total insurance claims payout was NZD 28.2 million. *Flooding and Storm Lower North Island, including Whanganui* Another extreme weather caused severe flooding in the western region of the North and South Islands during June 18-21, 2015. Severely flooded regions were Wanganui, Koitiata, Waitotara, Marton, and Whangaehu from Manawatu-Wanganui, Levin and Hutt Vally from Wellington, Hokitika from West Coast, and Golden Bay from the Tasman-Nelson region. A total of 400 people were evacuated from the Wanganui, and many people living near the river left home due to floods. Some houses were severely damaged in Koitiata, and road access was blocked. An entire village in Waitotara was evacuated, and many homes and businesses in Marton were flooded. Whangaehu and Levin were cut off from the rest of the regions due to flooding. Parts of Hutt Vally and Hokitika were flooded, and residents were evacuated. The total insurance claims amounted to NZD 41.5 million.
2014	*Easter Weekend Storm and Floods* An extreme weather event brought heavy rain and strong wind to New Zealand and caused flooding from April 17-19, 2014. A severe flood occurred at Takaka Hill of Tasman-Nelson, Otago, and Five Forks of Otago. Most of the damage occurred to houses and contents, commercial property, and motor vehicles. Flooding in Takaka Hill caused the closure of the highway road access. Floodwater entered houses in Otago and Maheno and Five Forks areas. Roads and houses went under floodwater in the Bay of Plenty. Total insurance claims payment reached NZD 55.3 million.
2013	*Nelson/Bay of Plenty storm and floods* A large and complex low-pressure system brought heavy rainfall resulting in severe floods to different parts of New Zealand from April 19-22, 2013. The worst flood-affected areas were Tauranga from the Bay of Plenty, Stoke and

	Richmond from Tasman-Nelson, and Hamilton from Waikato. Homes were flooded in Ta Tauranga city, and people were evacuated. Severe damages to roads and pathways occurred in Stoke and Richmond. The insurance claims payment amounted to NZD 46.2 million.
2011	*Storm/Flooding Bay of Plenty to Northland* Heavy rainfall brought severe flooding across Noth Island from January 28-29, 2011. The worst affected areas were Paihia and Pipiwai from Northland, Auckland City from Auckland, and Tauranga from the Bay of Plenty. Floods caused damage to the water treatment plant in Paihia, and people were evacuated from Pipiwai. All roads blocked the Auckland suburb of Clevedon. Residents in Tauranga were asked to conserve water due to sewage overflows. The total insurance claims payment reached NZD 19.8 million. *Nelson Floods* Another flood event occurred during December 15-16, 2011, in the Tasman-Nelson region. Several areas were flooded, including Richmond, Pohara, Cable Bay, and Golden Bay. A state of emergency was declared in the region. Homes were flooded, and people were evacuated from Richmond, Pohara, Cable Bay, and Golden Bay. The total insurance claims payout was NZD 16.8 million.
2010	*Flooding - Northland/Coromandel/Eastern BOP* Heavy rainfall caused flooding in several regions of North Island during the period June 1, 2010. Auckland City from Auckland, Whenuakite of Waikato, Whakatane, Edgecumbe, Matata, Opotiki, and Mount Maunganui from the Bay of Plenty was the worst flood-affected areas. Homes, shops, and industrial parks in Auckland city were flooded. Many roads were cut off in Whenuakite. Flooding occurred in Edgecumbe, Matata, and Opotiki, causing road closures and evacuation of people. Flood water entered the homes in low-lying areas in Opotikim and Matata. The total insurance claims payment amounted to NZD 12.5 million.
2005	*Flooding - BOP Tauranga / Matata* Heavy and persistent rainfall caused severe flooding to some places in North Island on May 18, 2005. The flooded affected areas were Whangamata,

	Opoutere and Pauanu from Waikato, Pongakawa, Awakaponga, Edgecumbe, Matata, Papamoa, Mount Maunganui and Welcome Bay from Bay of Plenty. Heavy rain caused the localized flood in Pongakawa, Awakaponga, and Edgecumbe. A number of houses went under mudslides, and a considerable volume of debris spread across the area in Matata, causing the destruction of 27 homes mad 87 properties. People were evacuated from Papamoa due to flooding. A total of NZD 28.5 million was paid as insurance claims payment.
2004	*Eastern Bay of Plenty Floods* Heavy and excessive rain caused flood events in the Bay of Plenty region during July 17-19, 2004. Mainly, the areas of Whakatane and Opotiki Districts experienced the world impact of the flood. Excessive rain caused a widespread flood across the regions. Many properties underwent water, and 700 were flooded in Whakatane. About 17,000 ha of land remained under water. The total insurance claim payment reached NZD 17.6 million.
2002	*North Island Flooding / Storm Damage* An excessive rainfall brought by extreme weather caused flooding in some places of the North Island region during the period June 21, 2002. Flood occurred at Hikurangi, Kaitaia, Kawakawa, Mangkahia River Catchment, Maungaturoto, Moerewa, Otiria, Paihia, Taheke, Tangiteroria, Tangowahire, Wahue, Whangarei Heads, from Northland, Port Charles Tararu, Tepuru and Tirau from Waikato, Mamaku from Bay of Plenty. Heavy rain caused flooding in parts of the Waikato and Coromandel regions. A state of emergency was declared in Waikato. A large number of public and private properties were destroyed. People were evacuated from flooded homes. The total insurance claims payment amounted to NZD 21.5 million.

Source: Insurance Council of New Zealand (ICNZ, 2021) and NIWA (2021b)

Appendix Table 3.2: Flood Effects on Income at Individual Level (Standardized Coefficients)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	0.00891	-0.0189	-0.0230	-0.00463
	(0.0212)	(0.0215)	(0.0271)	(0.0226)
$Flood_{it-1}$	0.0145	0.00643	-0.0260	0.00271
	(0.0232)	(0.0218)	(0.0282)	(0.0246)
$Flood_{it}$	-0.00150	0.0105	-0.0329	-0.0153
	(0.0223)	(0.0254)	(0.0241)	(0.0230)
$Flood_{it+1}$	0.0181	0.00225	0.00496	0.0200
	(0.0226)	(0.0235)	(0.0204)	(0.0224)
$Flood_{it+2}$	0.0165	0.00337	-0.0226	0.00584
	(0.0219)	(0.0216)	(0.0273)	(0.0231)
R^2 (within)	0.142	0.004	0.003	0.149
R^2 (between)	0.006	0.018	0.003	0.013
Number of individuals	2,304,690	2,304,690	2,304,690	2,304,690
Number of observations	28,418,127	28,418,127	28,418,127	28,418,127

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.3: Flood Effects on Above-median Income at Individual level (Standardized Coefficients)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-0.0118	-0.0937	-0.00814	0.00920
	(0.0294)	(0.0761)	(0.0237)	(0.0309)
$Flood_{it-1}$	0.00587	0.00601	-0.0331	0.00996
	(0.0323)	(0.0722)	(0.0286)	(0.0373)
$Flood_{it}$	0.00376	0.0743	-0.0358	-0.0108
	(0.0294)	(0.0761)	(0.0242)	(0.0320)
$Flood_{it+1}$	-0.0138	0.0249	0.00244	0.00226
	(0.0316)	(0.0768)	(0.0201)	(0.0324)
$Flood_{it+2}$	-0.0121	-0.0245	-0.0302	-0.0229
	(0.0284)	(0.0779)	(0.0273)	(0.0319)
R^2 (within)	0.259	0.061	0.005	0.203
R^2 (between)	0.007	0.006	0.004	0.012
Number of individuals	1,557,894	969,213	2,300,352	1,565,505
Number of observations	13,556,328	5,491,746	27,831,456	13,287,258

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.4: Flood Effects on Below-median Income at Individual level (Standardized Coefficients)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	0.00314	-0.00106	-0.0279	-0.00138
	(0.00957)	(0.000920)	(0.0715)	(0.0107)
$Flood_{it-1}$	-0.00670	-0.00162**	0.0931	-0.000214
	(0.00942)	(0.000756)	(0.0651)	(0.0105)
$Flood_{it}$	-0.00310	-0.00138	0.0457	-0.00253
	(0.00920)	(0.000754)	(0.0648)	(0.0105)
$Flood_{it+1}$	0.0113	-0.00113	0.114**	0.0128
	(0.00972)	(0.000846)	(0.0575)	(0.0104)
$Flood_{it+2}$	0.00263	-0.00140	0.0672	0.00634
	(0.00942)	(0.000773)	(0.0886)	(0.0100)
R^2 (within)	0.006	0.004	0.003	0.024
R^2 (between)	0.033	0.006	0.001	0.056
Number of individuals	2,104,374	2,179,218	211,197	2,124,102
Number of observations	14,861,796	22,926,381	586,671	15,130,866

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses. ** $p<0.05$, *** $p < 0.01$.

Appendix Table 3.5: Flood Effects on Individual Income of Male Group

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	992.1	-42.14	-567.8	382.1
	(1,197)	(164.3)	(846.9)	(1,361)
$Flood_{it-1}$	752.8	123.7	-471.0	405.5
	(1,281)	(169.1)	(979.6)	(1,493)
$Flood_{it}$	-572.6	264.5	-1,019	-1,327
	(1,294)	(216.4)	(774.0)	(1,401)
$Flood_{it+1}$	-79.56	-42.93	28.39	-94.11
	(1,277)	(137.5)	(695.2)	(1,324)
$Flood_{it+2}$	-449.8	-62.33	-411.4	-923.6
	(1,175)	(156.5)	(941.2)	(1,360)
R^2 (within)	0.144	0.008	0.003	0.146
R^2 (between)	0.009	0.018	0.005	0.018
Number of individuals	1,139,169	1,139,169	1,139,169	1,139,169
Number of observations	14,011,209	14,011,209	14,011,209	14,011,209

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.6: Flood Effects on Individual Income of Female Group

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-375.9	-161.6	-262.7	-800.2
	(1,060)	(153.1)	(488.3)	(1,120)
$Flood_{it-1}$	291.7	-65.69	-478.3**	-252.3
	(1,202)	(151.3)	(229.4)	(1,217)
$Flood_{it}$	429.4	-171.9	-165.7	91.90
	(1,071)	(151.2)	(399.9)	(1,130)
$Flood_{it+1}$	1,422	65.48	149.3	1,636
	(1,135)	(207.0)	(237.6)	(1,161)
$Flood_{it+2}$	1,657	94.92	-424.7	1,327
	(1,171)	(163.7)	(299.3)	(1,203)
R^2 (within)	0.150	0.002	0.005	0.167
R^2 (between)	0.005	0.016	0.001	0.011
Number of individuals	1,165,518	1,165,518	1,165,518	1,165,518
Number of observations	14,406,918	14,406,918	14,406,918	14,406,918

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses. ** $p<0.05$, *** $p < 0.01$.

Appendix Table 3.7: Flood Effects on Individual Income of Non-tertiary Education Certificate Group

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	24.54	-342.8	487.8	169.5
	(1,301)	(245.6)	(593.3)	(1,396)
$Flood_{it-1}$	70.92	107.4	-507.0	-328.7
	(1,367)	(274.1)	(511.0)	(1,394)
$Flood_{it}$	-1,279	137.5	-504.7	-1,646
	(1,280)	(272.0)	(474.0)	(1,301)
$Flood_{it+1}$	35.17	-124.7	-547.9	-637.4
	(1,100)	(270.7)	(476.0)	(1,156)
$Flood_{it+2}$	-474.1	97.17	-331.4	-708.3
	(1,168)	(296.8)	(486.4)	(1,117)
R^2 (within)	0.082	0.010	0.001	0.082
R^2 (between)	0.000	0.001	0.0001	0.001
Number of individuals	351,480	351,480	351,480	351,480
Number of observations	4,712,394	4,712,394	4,712,394	4,712,394

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.8: Flood Effects on Individual Income of Secondary Education Certificate Group

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	-22.01	50.74	-377.5	-348.8
	(1,243)	(195.4)	(977.5)	(1,492)
$Flood_{it-1}$	-121.4	362.2	-80.21	160.6
	(1,424)	(224.5)	(1,383)	(1,899)
$Flood_{it}$	-1,266	293.4	-604.6	-1,577
	(1,280)	(222.8)	(720.3)	(1,368)
$Flood_{it+1}$	-844.8	348.4	-30.98	-527.3
	(1,339)	(207.5)	(605.3)	(1,411)
$Flood_{it+2}$	-39.23	198.6	294.1	453.5
	(1,196)	(185.7)	(747.6)	(1,259)
R^2 (within)	0.139	0.004	0.003	0.137
R^2 (between)	0.032	0.019	0.005	0.050
Number of individuals	643,671	643,671	643,671	643,671
Number of observations	7,247,325	7,247,325	7,247,325	7,247,325

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.9: Flood Effects on Individual Income of Bachelor and Post-bachelor Education Certificate Group

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-1,106	-4.951	-1,177	-2,288
	(2,346)	(157.0)	(1,746)	(2,689)
$Flood_{it-1}$	36.76	-54.83	-846.1	-864.1
	(2,697)	(156.7)	(1,465)	(2,907)
$Flood_{it}$	-949.7	-29.56	-1,156	-2,136
	(2,542)	(147.7)	(1,566)	(2,832)
$Flood_{it+1}$	832.4	-154.1	911.0	1,589
	(2,541)	(158.2)	(1,194)	(2,637)
$Flood_{it+2}$	-544.9	-122.0	-762.3	-1,429
	(2,460)	(142.0)	(1,801)	(2,888)
R^2 (within)	0.197	0.0005	0.006	0.205
R^2 (between)	0.004	0.002	0.003	0.008
Number of individuals	566,838	566,838	566,838	566,838
Number of observations	7,268,907	7,268,907	7,268,907	7,268,907

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.10: Summary Statistics (Individual Income) (All Observations)

	Flooded Individual			Control Individuals
	Before Floods (1)	**During Floods (2)**	**After Floods (3)**	**During Floods (4)**
Mean	27,741.85	27,847.84	29,778.65	27,273.67
Std. Dev.	39,829.01	38,329.02	39,483.29	36,676.25
Observations	1,239	1,305	1,269	33,784,614
Mean	1,706.78	1,718.93	1,719.97	1,696.92
Std. Dev.	4,627.45	5,283.12	5,062.34	4,872.59
Observations	1,239	1,305	1,269	33,784,614
Mean	1,756.50	1,862.11	2,350.20	2,013.88
Std. Dev.	15,953.21	1,3142	15,971.75	16,820.29
Observations	1,239	1,305	1,269	33,784,614
Mean	31,205.14	3,1428.88	33,848.82	30,984.48
Std. Dev.	41,260.97	39,021.55	40,920.57	38,576.52
Observations	1,239	1,305	1,269	33,784,614

Note: Income figures are measured in New Zealand Dollars.

Appendix Table 3.11: Flood Effects on Individual Income (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	942.9	-83.88	-679.5	179.5
	(722.6)	(103.0)	(452.1)	(827.8)
$Flood_{it-1}$	1,205	37.84	-697.4	545.4
	(782.0)	(101.9)	(462.1)	(884.1)
$Flood_{it}$	858.7	55.08	-613.2	300.5
	(753.3)	(118.3)	(380.1)	(819.6)
$Flood_{it+1}$	1,328	28.03	-135.0	1,221
	(796.3)	(110.3)	(357.8)	(847.5)
$Flood_{it+2}$	1,153	-15.07	-353.5	784.4
	(750.9)	(100.0)	(407.1)	(825.2)
R^2 (within)	0.071	0.001	0.002	0.070
R^2 (between)	0.011	0.008	0.002	0.018
Number of individuals	2,399,290	2,399,290	2,399,290	2,399,290
Number of observations	33,785,919	33,785,919	33,785,919	33,785,919

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.12: Flood Effects on Above-median Income at Individual level (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-462.3	485.6	6,898	-194.7
	(997.2)	(987.6)	(11,660)	(1,046)
$Flood_{it-1}$	316.0	631.2	6,533	676.2
	(1,122)	(851.2)	(16,123)	(1,206)
$Flood_{it}$	101.1	1,417	-4,277	-412.6
	(1,039)	(1,348)	(7,040)	(1,047)
$Flood_{it+1}$	-224.8	3,305	-3,848	-87.90
	(1,116)	(2,896)	(8,099)	(1,127)
$Flood_{it+2}$	-302.1	-189.2	-4,763	-550.2
	(1,018)	(3,092)	(9,149)	(1,090)
R^2 (within)	0.251	0.045	0.034	0.195
R^2 (between)	0.004	0.0003	0.0003	0.005
Number of individuals	1,669,944	58,287	231,492	1,793,124
Number of observations	15,231,585	175,005	962,670	16,786,554

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.13: Flood Effects on Below-median Income at Individual level (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-204.1	-88.10	26.92	-332.8
	(194.3)	(81.20)	(77.52)	(255.7)
$Flood_{it-1}$	-256.8	48.09	25.02	-140.7
	(196.7)	(83.46)	(82.23)	(249.4)
$Flood_{it}$	-4.528	-36.24	-88.31	-197.8
	(202.5)	(82.89)	(73.15)	(246.3)
$Flood_{it+1}$	181.5	5.921	-36.89	113.1
	(198.2)	(85.30)	(71.96)	(241.8)
$Flood_{it+2}$	115.1	-39.56	19.14	173.7
	(184.5)	(81.53)	(64.57)	(234.7)
R^2 (within)	0.005	0.001	0.000	0.001
R^2 (between)	0.004	0.010	0.0001	0.002
Number of individuals	2,168,685	2,398,620	2,394,912	2,138,172
Number of observations	18,554,337	33,610,914	32,823,249	16,999,368

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.14: Flood Effects on Income at Individual Level (Standardized Coefficients) (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	0.0257	-0.0172	-0.0404	0.00465
	(0.0197)	(0.0211)	(0.0269)	(0.0215)
$Flood_{it-1}$	0.0329	0.00777	-0.0415	0.0141
	(0.0213)	(0.0209)	(0.0275)	(0.0229)
$Flood_{it}$	0.0234	0.0113	-0.0365	0.00779
	(0.0205)	(0.0243)	(0.0226)	(0.0212)
$Flood_{it+1}$	0.0362	0.00575	-0.00802	0.0317
	(0.0217)	(0.0226)	(0.0213)	(0.0220)
$Flood_{it+2}$	0.0314	-0.00309	-0.0210	0.0203
	(0.0205)	(0.0205)	(0.0242)	(0.0214)
R^2 (within)	0.071	0.001	0.002	0.070
R^2 (between)	0.011	0.008	0.002	0.018
Number of individuals	2,399,289	2,399,289	2,399,289	2,399,289
Number of observations	33,785,919	33,785,919	33,785,919	33,785,919

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.15: Flood Effects on Above-median Income at Individual level (Standardized Coefficients) (All Observations)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	-0.0101	-0.0483	-0.0328	-0.00501
	(0.0267)	(0.0781)	(0.0249)	(0.0271)
$Flood_{it-1}$	0.0132	0.0388	-0.0484	0.0174
	(0.0295)	(0.0776)	(0.0275)	(0.0313)
$Flood_{it}$	0.00643	0.0716	-0.0402	-0.0107
	(0.0273)	(0.0908)	(0.0225)	(0.0271)
$Flood_{it+1}$	0.00174	0.0605	-0.0117	-0.00228
	(0.0293)	(0.0787)	(0.0210)	(0.0292)
$Flood_{it+2}$	-0.00783	-0.00691	-0.0280	-0.0142
	(0.0275)	(0.0853)	(0.0240)	(0.0283)
R^2 (within)	0.246	0.058	0.002	0.195
R^2 (between)	0.004	0.006	0.003	0.006
Number of individuals	1,726,125	1,060,461	2,398,803	1,793,124
Number of observations	16,092,303	5,991,096	33,392,175	16,786,554

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.16: Flood Effects on Below-median Income at Individual level (Standardized Coefficients) (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	-0.00383	-1.33e-05	0.0147	-0.00866
	(0.00450)	(0.000210)	(0.0940)	(0.00663)
$Flood_{it-1}$	-0.00945**	-0.000174	0.171	-0.00393
	(0.00430)	(0.000144)	(0.103)	(0.00647)
$Flood_{it}$	-0.00311	7.79e-05	0.0609	-0.00516
	(0.00456)	(0.000172)	(0.0903)	(0.00639)
$Flood_{it+1}$	0.00402	0.000193	0.252***	0.00292
	(0.00455)	(0.000193)	(0.0939)	(0.00627)
$Flood_{it+2}$	0.00516	-6.01e-05	0.284	0.00448
	(0.00437)	(0.000155)	(0.234)	(0.00608)
R^2 (within)	0.005	0.002	0.003	0.001
R^2 (between)	0.004	0.002	0.0004	0.002
Number of individuals	2,132,988	2,304,255	151,236	2,138,172
Number of observations	17,693,616	27,794,826	393,741	16,999,365

Regression coefficients are expressed in standardized coefficients; all regressions include year and individual fixed effects. The median income is calculated from total individual income from the flood-affected areas in the previous year. Clustered standard errors (at the individual level) are in parentheses. ** p<0.05, ***p < 0.01.

Appendix Table 3.17: Flood Effects on Individual Income of Male Group (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	1,332	-35.45	-700.0	596.3
	(1,086)	(150.9)	(726.3)	(1,264)
$Flood_{it-1}$	1,418	101.2	-611.1	908.4
	(1,149)	(153.6)	(826.4)	(1,354)
$Flood_{it}$	458.8	218.6	-944.7	-267.2
	(1,159)	(195.4)	(658.7)	(1,269)
$Flood_{it+1}$	549.5	-20.77	-27.98	500.8
	(1,221)	(136.4)	(602.6)	(1,293)
$Flood_{it+2}$	-74.23	-113.3	-317.8	-505.3
	(1,091)	(140.6)	(752.4)	(1,243)
R^2 (within)	0.069	0.002	0.001	0.066
R^2 (between)	0.014	0.012	0.003	0.022
Number of individuals	1,174,821	1,174,821	1,174,821	1,174,821
Number of observations	16,603,467	16,603,467	16,603,467	16,603,467

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.18: Flood Effects on Individual Income of Female Group (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	520.8	-136.9	-657.7	-273.7
	(942.7)	(138.3)	(520.3)	(1,050)
$Flood_{it-1}$	958.4	-31.99	-787.7**	138.7
	(1,057)	(131.7)	(368.6)	(1,119)
$Flood_{it}$	1,239	-121.7	-266.9	850.6
	(951.2)	(128.6)	(359.3)	(1,022)
$Flood_{it+1}$	2,105**	75.55	-253.4	1,927
	(1,011)	(174.7)	(368.3)	(1,085)
$Flood_{it+2}$	2,374**	81.55	-398.4	2,057
	(1,033)	(141.6)	(263.0)	(1,076)
R^2 (within)	0.081	0.001	0.003	0.084
R^2 (between)	0.012	0.009	0.002	0.019
Number of individuals	1,224,471	1,224,471	1,224,471	1,224,471
Number of observations	17,182,455	17,182,455	17,182,455	17,182,455

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses. ** $p<0.05$, *** $p < 0.01$.

Appendix Table 3.19: Flood Effects on Individual Income of Non-tertiary Education Certificate Group (All Observations)

	Wage & Salary (1)	Benefit & Compensation (2)	Self-employment (3)	Wage, Benefit & Self-employment (4)
$Flood_{it-2}$	126.9	-394.0	445.8	178.7
	(1,013)	(206.7)	(453.8)	(1,099)
$Flood_{it-1}$	261.0	-4.748	-347.7	-91.46
	(1,085)	(225.7)	(384.2)	(1,122)
$Flood_{it}$	-630.3	69.45	-326.2	-887.1
	(1,036)	(232.5)	(357.5)	(1,071)
$Flood_{it+1}$	43.00	-108.4	-353.2	-418.6
	(1,031)	(216.4)	(351.2)	(1,081)
$Flood_{it+2}$	-31.63	21.63	-152.8	-162.9
	(1,017)	(240.4)	(355.4)	(1,005)
R^2 (within)	0.018	0.001	0.000	0.013
R^2 (between)	0.009	0.001	0.001	0.014
Number of individuals	384,924	384,924	384,924	384,924
Number of observations	6,352,833	6,352,833	6,352,833	6,352,833

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.20: Flood Effects on Individual Income of Secondary Education Certificate Group (All Observations)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	903.7	-2.617	-292.9	608.1
	(1,177)	(181.0)	(820.1)	(1,434)
$Flood_{it-1}$	646.1	279.6	-91.98	833.6
	(1,316)	(192.5)	(1,110)	(1,702)
$Flood_{it}$	-30.21	212.1	-487.4	-305.4
	(1,181)	(191.7)	(548.5)	(1,255)
$Flood_{it+1}$	449.2	273.5	58.22	780.9
	(1,228)	(187.9)	(480.1)	(1,280)
$Flood_{it+2}$	456.1	128.2	213.1	797.4
	(1,222)	(171.6)	(590.4)	(1,279)
R^2 (within)	0.065	0.001	0.001	0.061
R^2 (between)	0.065	0.012	0.004	0.055
Number of individuals	671,232	671,232	671,232	671,232
Number of observations	8,703,882	8,703,882	8,703,882	8,703,882

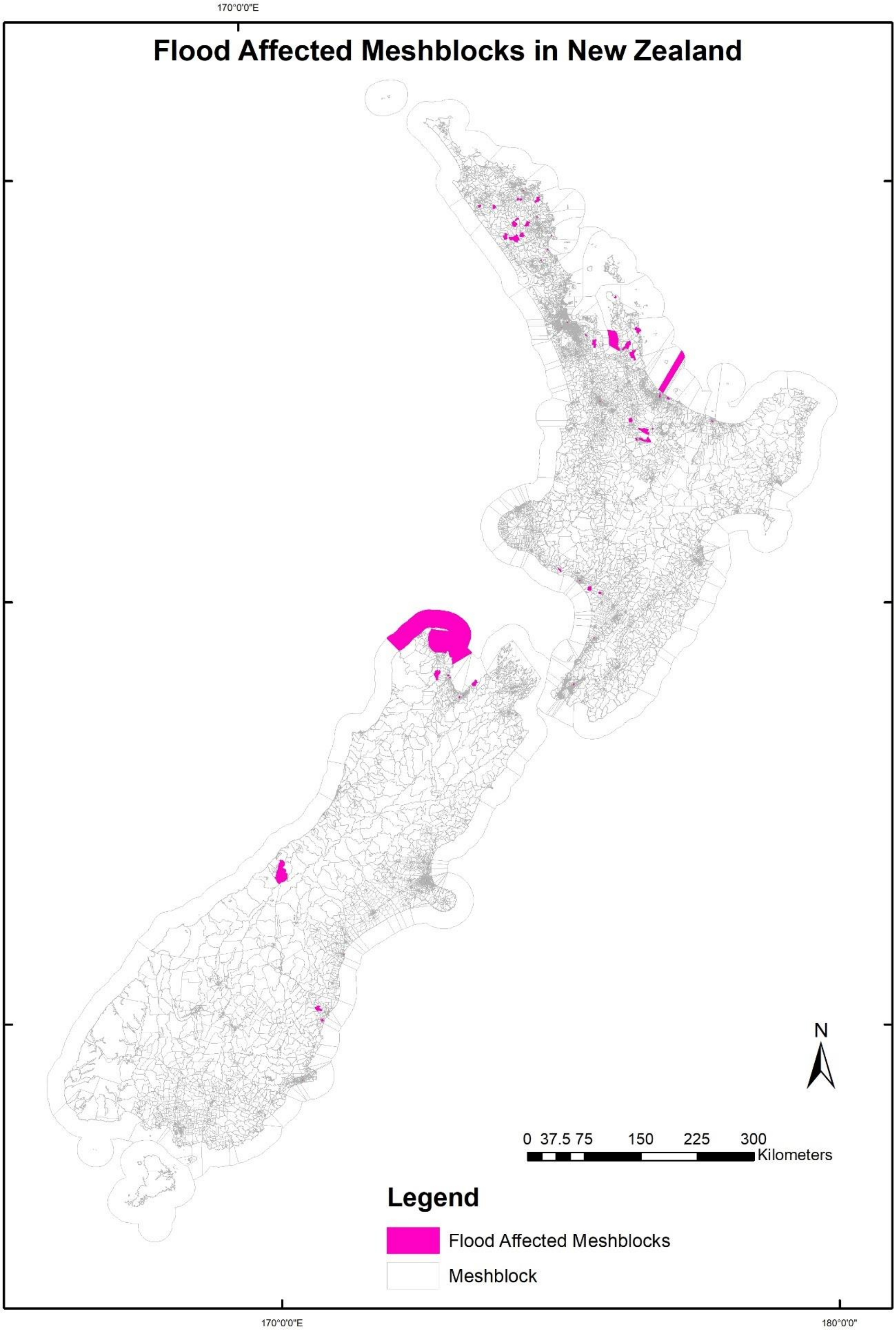
Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Table 3.21: Flood Effects on Individual Income of Bachelor and Post-bachelor Education Certificate Group (All Observations)

	Wage & Salary (1)	**Benefit & Compensation (2)**	**Self-employment (3)**	**Wage, Benefit & Self-employment (4)**
$Flood_{it-2}$	-473.5	-9.046	-1,900	-2,383
	(2,217)	(136.7)	(1,658)	(2,594)
$Flood_{it-1}$	830.0	-61.78	-1,461	-692.5
	(2,510)	(137.8)	(1,447)	(2,777)
$Flood_{it}$	425.6	-16.69	-1,034	-625.0
	(2,388)	(131.9)	(1,434)	(2,686)
$Flood_{it+1}$	1,132	-125.5	274.6	1,282
	(2,560)	(135.9)	(1,248)	(2,735)
$Flood_{it+2}$	491.4	-116.6	-711.4	-336.5
	(2,301)	(124.9)	(1,612)	(2,704)
R^2 (within)	0.130	0.001	0.004	0.131
R^2 (between)	0.006	0.011	0.002	0.009
Number of individuals	576,117	576,117	576,117	576,117
Number of observations	8,026,098	8,026,098	8,026,098	8,026,098

Regression coefficients are expressed in New Zealand Dollars; all regressions include year and individual fixed effects. Clustered standard errors (at the individual level) are in parentheses.

Appendix Figure 3.1: Flood Affected Meshblocks in New Zealand



CHAPTER FOUR : IMPACT OF EXTRATROPICAL CYCLONES, FLOODS, AND WILDFIRES ON FIRMS' FINANCIAL PERFORMANCE IN NEW ZEALAND

Abstract

The purpose of the research is to empirically investigate the impact of extratropical cyclones, floods, and wildfires on the profitability of firms operating in New Zealand. We utilize a comprehensive administrative database of all firms from Statistics New Zealand's Longitudinal Business Database from the financial year 2011- 2020 for extratropical cyclones and 2001-2020 for floods and wildfires. A set of panel regressions with the firm- and time-fixed effects has been estimated to assess the impact of extratropical cyclones, floods, and wildfires on firms' profit and business equity. We find that the annual profit of extratropical cyclone-affected firms in agriculture, wholesale trade, financial and insurance services, and transportation sectors decreased significantly compared with the unaffected firms in the cyclone year. The study findings also indicate that floods had no significant effect on the firm's profit, and wildfires had no significant impact on the forestry firms' profit. Besides, we found no substantial evidence of the impact of extratropical cyclones, floods, and wildfires on the firms' business equity.

4.1 INTRODUCTION

The unique midlatitude geographic location of Aotearoa New Zealand makes the country highly vulnerable and exposed to extreme weather events, including extratropical cyclones, heavy rain, flood, drought, and wildfire (McAneney et al., 2022). During the last decades, New Zealand experienced the landfall of extratropical cyclones in many parts of the country (Lorrey et al., 2014). The Historical Weather Events (HWE) Catalogue published by the National Institute of Water and Atmospheric Research recorded that 16 extratropical cyclones hit New Zealand from 1996 to 2020 (NIWA, 2022). Extratropical cyclones caused significant damage to residential and commercial property and disrupted horizontal infrastructures, including power, roads, and energy networks. For instance, Extratropical cyclone Gita (2018) caused damage to roofs, broke down trees and power lines, and flooded houses and businesses in the Tasman, West Coast, Wellington, Taranaki, and Canterbury regions of the country (Daly, 2018). Extratropical cyclone Debbie (2017) brought adverse economic effects through prolonged flooding to the dairy farmlands covering 3,500 hectares in the Bay of Plenty region of New Zealand (Paulik et al., 2021).

Over the past decades, extratropical cyclones appeared as one the costliest extreme weather events in the United States, Europe, and Asia. For example, Hurricane Sandy was one of the costliest hurricanes that underwent a tropical to extratropical transition at the time of landfall on the east coast of the United States in October 2012. Sandy caused over USD60 billion in reported economic damage through widespread coastal flooding (Strauss et al., 2021). Hurricane Sandy caused an economic loss for the locally customer-dependent retail businesses in New York City. The post-Sandy effects indicated that retail businesses from highly flooded blocks faced an 11 percent increase in establishment closure probability than those in the low flooded blocks (Meltzer et al., 2021). In addition, the effects were higher for heavily flooded city blocks, especially in Brooklyn and Queens, than in the less flooded area (Manhattan) of the businesses situated in New York City. The relocation rate of business establishments in the neighborhoods was higher for hurricane-affected companies than for unaffected ones (Indaco et al., 2021). Besides, the coastal towns and fishing communities in New York and New Jersey experienced the adverse impact of Hurricane Sandy in terms of damages to fishing infrastructure, disruptions in fishing patterns for some species, and losses in revenue. For example, fishing and fishing-related businesses faced an estimated uninsured loss of USD200 million and USD250 million in New York and New Jersey, respectively.

Extratropical cyclones impacting European countries (e.g., Spain, Portugal, France, Germany, Ireland, United Kingdom, and Norway) originate in the Atlantic and produce extreme weather conditions such as heavy rain, strong wind, and high waves. The economic losses of the extratropical cyclone are substantial across Europe (Sainsbury et al., 2022). For instance, three mid-latitude windstorms Kyrill (2007), Xynthia (2010), and David (2018), were the costliest storms that occurred after 2000 in Europe. The total economic damage caused by these three storms was approximately USD10.3 billion (Lau et al., 2022). Being located in the western North Pacific basin, Japan is also susceptible to frequent landfall of extratropical cyclones, which bring heavy rain and strong wind. A recent typhoon in Japan, Typhoon Hagibis, hit the eastern part of the country in October 2019 and caused an economic loss of over USD10 billion dollars (Li & Otto, 2022).

Flood is another extreme weather event that causes damage to property and infrastructure, disruption in commercial business activities, and economic loss. For instance, the financial loss caused by floods in the Australian economy has increased in past years. The estimated insured claims cost of the recent February-March 2022 Flood event in South-East Queensland and coastal New South Wales became AUD3.35 billion, marking the event as the costliest flood in Australia's history (Insurance Council of Australia, 2022). The resulting impacts were a decline in the gross value added of industries such as coal mining (2.7 percent) and construction (1.8 percent) for the quarter (Australian Bureau of Statistics, 2022). Flash floods have caused insured losses of USD54 billion (€46 billion) in 2021 in Europe. The flood in 2000 caused a short-run negative impact on the productivity of flooded manufacturing firms compared with firms that were not flooded in 40 European countries (Leiter et al., 2009). However, the short-run effect of a major flood (2010) on firms' performance in Veneto, Italy, was visible just after the flood but was not statistically significant. Besides, financial aid just after the flood helped the firms in the recovery phase (Coelli & Manasse, 2014). After the 2009 flood, the small- and medium-sized enterprises (SMEs) operations experienced a range of impacts, such as damage to property and stock and disruption in supply chain and logistics activities in Cockermouth, United Kingdom. The enterprises outside the flooded area also experienced short-term impacts regarding travel difficulties and increased cost of post-flood insurance (Wedawatta et al., 2014). In Germany, the estimated flood-induced cost reached USD40 billion in 2021, marking flooding as the costliest natural disaster in Germany to date (Munich Re, 2022). Floods also cause significant economic damage to household property, agriculture, business, and infrastructure in the United States each year. The 2019 Great Flood in the Midwestern United States was responsible for about USD6.3 billion in damages to property and agriculture and disruption to the operation of many industries in the region (Sun et al., 2022).

In China, unexpected flooding events from 2003 to 2019 caused a significant negative impact on future firm performance (Tobin's Q and return on assets), and regular (well-expected) flooding had no significant effect on firms' future performance of 247 cities (Pan & Qiu, 2022). Besides, Hu et al. (2019) indicated that, on average, 127 major floods from 2003 to 2010 reduced Chinese manufacturing firms' outputs (measured by labor productivity) by about 28.3 percent per year. The macroeconomic impact was a 12.3 percent annual loss of total production. Floods also had significant adverse short-run effects on the growth indicators of manufacturing and service sectors of selected 24 Indian states from 1990 to 2015 (Panwar & Sen, 2020). Additionally, the 2013 River flood caused an average loss of USD854 for each flooded business unit in a densely populated area in Jakarta, Indonesia. Around 93 percent of the flood-affected business units faced an average five-day closure after the flood.

Over the past decades, the occurrence of wildfires has increased and caused an unprecedented loss of human and wildlife habitat, and destruction of property and forests land in many regions, including the United States, Australia, and Europe (Lang & Moeini-Meybodi, 2021). Every year, fires burn more than 400 million hectares of land globally. A major wildfire event occurred in California, USA, in 2018 and caused estimated damage totaling USD148.5 (USD126.1–USD192.9) billion. Out of the total damage, capital losses, health costs, and indirect losses were USD27.7, USD32.2, and USD88.6 billion, respectively (Wang et al., 2021). Bushfire is also a frequently occurring natural hazard contributing to a devastating economic impact in Australia. In 2019-20, bushfires caused an estimated insurance claim loss to be AUD2.3 billion, with more than 38,000 claims from houses and small businesses nationwide (Insurance Council of Australia, 2020). In recent years, European countries, especially in the southern Medetterian countries, including Portugal, Spain, Italy, Greece, and the Mediterranean region of France, have repeatedly experienced more significant forest fire events. Wildfires caused damage to 0.5 million hectares of European forest in 2010 (de Rigo et al., 2017; Tedim et al., 2015). The impact of wildfires can be negative or positive on the local economy. The adverse effects include short-run employment and wages decline in the natural resource and tourism sectors. The positive effect, however, is an increase in local employment growth attributed mainly to the agricultural sector due to the adoption of suppression efforts after the fire. For example, forest fires from 2008 to 2015 caused an increase in the overall output and employment in the local agroforestry sectors in Portuguese municipalities from 2011-2012. However, in the burnt areas, employment growth increased in the agricultural sector and decreased in the forestry sector (Martinho, 2019). In addition, the 2008 Wildfires caused a 30 percent increase in employment and a 19 percent decrease in the average wage in privately owned natural resource firms compared to the previous year in Trinity County, California, United States (Davis et al., 2014).

Until now, we are unaware of any research in the existing literature focusing on the micro-level impact of extratropical cyclones, floods, and wildfires on business firms operating in New Zealand. We consider our study the first in the New Zealand context to empirically investigate the effects of extratropical cyclones, floods, and wildfires on the financial performance of firms using the administrative firm-level annual panel data from Statistics NZ's Longitudinal Business Database (LBD). The study's research question is: What were the effects of extratropical cyclones, floods, and wildfires on the annual profit of different business firms operating in the extratropical cyclone-affected regions of New Zealand? In addition, we also examined the impacts of extratropical cyclones, floods, and wildfires on the firms' business equity.

The remaining sections of the paper are organized as follows: Section 2 discusses relevant literature on the impacts of extratropical cyclones, floods, and wildfires on business firms across the countries. Section 3 presents data source and estimation strategies. Section 4 demonstrates the results and discussion, and Section 5 states the conclusion.

4.2 LITERATURE REVIEW

Recent studies regarding the economic impacts of extratropical cyclones have mainly concentrated on the aggregate national or global level assessment of economic loss (Hanson et al., 2004; Kunz et al., 2013; Leckebusch et al., 2007; Narita et al., 2010; Park et al., 2017; Pinto et al., 2007). A few studies investigated extratropical cyclones' local or micro-level impacts on the financial status of business firms. For instance, in a case study, Paulik et al. (2021) assessed the effect of extratropical cyclone Debbie (2017) on the five dairy farms located in the Bay of Plenty region, New Zealand using a semi-structured interview and post-event survey regarding the information on flood description, actions taken before and after the flood, direct and indirect cost of the flood, damage on production and capital, and recovery challenges. The study findings revealed that the affected dairy farms experienced different direct and indirect costs, and the daily operation of the farms was disrupted. The long-standing flood water and siltation due to extratropical cyclone Debbie damaged the farm production process, destroyed capital assets, and impacted the farm owners' well-being. In a recent study, Okubo and Strobl (2021) investigated the impact of super typhoon Vera/ Ise Bay Typhoon (1959) on business firms' survival and financial performance in the Ise Bay of Nagoya City, Japan. Using firm-level data and a map of flooding areas, they found that retail and warehouse firms had a smaller ability to survive after the typhoon. In contrast, manufacturing firms had a greater chance of surviving after being affected by typhoon-induced floods. There was heterogeneity in the performance across the surviving firms, such as firms in manufacturing and construction upgraded the likely damaged capital, and the sales of wholesale sector firms declined in the face of the local flood and increased in the event of flooding in the neighborhood regions.

Flooding events are responsible for causing direct and indirect losses to businesses and infrastructure. The impact of floods on firms' financial performance in post-flood times varies depending on the location, firm type, financial strength, previous flood experience, and post-flood financial assistance. Previous research studies have outlined that floods positively and negatively influence firms' financial performance in the post-flood period. For instance, Noth and Rehbein (2019) investigated the effect of the 2013 Elbe River Flood on the flooded firms' financial performance compared with unaffected firms. They used German firm-level data from the AMADEUS database containing 48,524 firms between 2010 to 2015 and flood damage data from the German Insurance Association. Using the postal code of each firm available in the AMADEUS database, they matched the firms with flood damage locations.

The study's findings indicated that the 2013 Flood had a positive effect on the flood-affected firms' performance (turnover) and liquidity (cash balance) and a decline in firms' leverage (indebtedness) after the post-flood year. They also mentioned several possible factors that might lead to positive effects after the flood, including previous flood experience, cut-off investment, employee layoff, compensation from the government and insurance policy, and productivity improvement due to the replacement of old capital with the new capital stock. Using nationwide county-level panel data from 1992 to 2012, Sun et al. (2022) estimated the different impacts of floods on overall local business sectors in the United States. The study findings showed that minor floods had a positive and major floods had a negative effect on the business sectors. They also found that floods positively influence service sectors, whereas it was negative for agriculture, mainly for large floods and small establishments. Also, Yamamoto and Naka (2021) analyzed the impact of flood damage on firms' financial conditions by combining panel financial data of flood-affected domestic firms and municipality-level Flood Statistics data from 1993 to 2018 in Japan. The study findings confirmed that flood significantly negatively impacted the firms' financial conditions, especially on the profit to sales ratio of manufacturing industry. Firms located in the municipalities with less frequency of flood occurrence experienced a more significant negative impact on profit to sales ratio in the short run. In the Australian context, Ulubaşoğlu et al. (2019) estimated the impact of 47 major floods on sectoral gross value added and outputs of major economic sectors using the sector-specific economic panel data from 1978 to 2014. The study concluded that floods' impact on overall gross value added was significantly negative. In addition, flood events reduced agricultural, mining, construction, retail, and financial output. In particular, the agriculture output in a flood-affected state declined by, on average, 5 to 6 percent in the flood year and the following year compared with an unaffected state. However, floods also positively affected some sectors, including utilities, public administration, and safety.

Wildfires' major impacts on economic sectors include loss of assets and commercial property, productivity loss of forest industries, decrease in real estate value due to perception of fire risk, and increase in the cost of health expenditure and post-fire rehabilitation (Lang & Moeini-Meybodi, 2021). Studies investigating the economic impact of wildfires at the local level are still understudied in the current literature. Nielsen-Pincus et al. (2013) examined the impact of wildfires on local employment and wage growth in western US counties. They used 413 county-level growth and employment and wage panel data from the Bureau of Labor Statistics

(BLS) Quarterly Census of Employment and Wages (QCEW) between 2004 and 2008. The study findings showed a positive impact of wildfires on employment (1.0 percent increase) and wage (0.8% increase) during the quarter of a wildfire. However, in another research, Nielsen-Pincus et al. (2014) also identified the impact of wildfires on employment growth across different sectors. They found that during the wildfires, the natural resources and mining sector experienced positive growth (2.44 percent), whereas the leisure and hospitality sectors faced negative growth (-2.71 percent). Using panel data from the 2002-2019 financial years at the suburb-level (SA4-level) of Australia, Hickson and Marshan (2022) estimated that bushfires raised the likelihood of male labor force participation in the mining (6.4 percent) and transportation (6.0 percent) sectors while the services sectors experienced a declining trend in female employment. The domination of males in the mining and transport sectors (more than three-quarters of the employment) might explain the reasons for increasing male employment after bushfires. In a similar study, Ulubaşoğlu et al. (2019) investigated the impact of 36 major bushfires on the gross value added of major economic sectors using the state-level panel data from 1978-2014 in Australia. They found no statistical evidence of the significant impact of bushfires on the overall gross value added and on outputs from agriculture, mining and manufacturing sectors in an economically meaningful way. However, the study also indicated that bushfires had adverse impact on the output of construction, transportation, and the financial and insurance sector and positive impacts on the utilities and retail sectors.

4.3 METHODOLOGY

4.3.1 Data Type and Source

The primary data source we use is Statistics New Zealand's Longitudinal Business Database (LBD)[3]. The LBD contains administrative- and survey-based rich financial data sources for understanding the behavior of all businesses operating in New Zealand. More specifically, we use firm-level annual financial data from the Annual Enterprise Survey (AES) of LBD. Our data time frame covers the financial tax year 2011 (1 April 2010 - 31 March 2011) to 2020 (1 April 2019 - 31 March 2020) for estimating the impact of extratropical cyclones on firms' financial performance. The data covers the financial years 2001 (April 2000-March 2001) to 2020 (April 2019-March 2020) to estimate the impacts of floods and wildfires on the firm's financial performance during that time.

4.3.2 Firm Financial Data from Annual Firm Survey (AES)

Firm-level firm financial (tax) data are available at the Annual Enterprise Survey (AES) of the Longitudinal Business Database (LBD), Statistics New Zealand. We use AES annual data from the financial tax year from 2011 to 2020. The Annual Enterprise Survey (AES) is the most comprehensive source of yearly financial performance and financial position data of economically-significant[4] firms operating in New Zealand. AES data cover almost 80 percent of New Zealand's Gross Domestic Product (GDP). The primary purpose of AES is to provide annual data for financial performance and financial position in different industries and intuitional sectors. AES contains data compiled from sources:

i. a sample survey of business financial data[5]
ii. business financial data from Inland Revenue (IR10)
iii. not-for-profit data from charities services, which is the branch of the Department of Internal Affairs.

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[3] See Fabling and Sanderson (2016), pp.16-19, for discussion on purpose, content, and coverage of AES.
[4] An economically-significant enterprise is defined as an enterprise if it fulfils any one of the following conditions: has greater than $30,000 annual Goods and Services Tax (GST) expenses or sales; has more than 3 paid employees; is in a GST exempt industry, other than residential property leasing and rental; is part of a Business Register (BR) group; is a new GST registration and has registered for Salaries and Wages PAYE; is a new GST registration and is part of a IRD GST group return; has a geographic unit classified to agriculture, it is alive on the BR, it is classified as economically significant; has IR10 income greater than $40,000 annually.
[5] A stratified random sample is selected to receive the annual postal survey from all active business. The details of the sampling procedure are available at: https://datainfoplus.stats.govt.nz/Item/nz.govt.stats/36809771-984d-4e6b-89a1-576f2118b05b.

The industry-level financial data collected in AES are used to calculate the Gross Domestic Product of New Zealand through the current price annual industry account. AES classifies industries based on the Australian and New Zealand Standard Industrial Classifications 2006 (ANZSIC06). AES is designed predominantly at the four-digit ANZSIC level (109 industries).

AES contains a wide variety of information on a firm's financial performance and financial position, including gross output, total income, total expenditure, profit, value-added, operating surplus, and salaries and wages of the employee. Additionally, it has information on various measures of sales and purchases, information on fixed and flexible assets and liabilities, and many more (see Fabling and Sanderson (2016) for further discussion). AES also contains information on business type, industry and institutional sectors, firm number, firm GST sales, and employee counts.

4.3.3 Industrial Classification

Annual Enterprise Survey (AES) collects industry-level information based on ANZSIC06 at level four. There are 19 broad *divisions* of industries (A-S) under ANZSIOC06 (Appendix Table 1). For example, A = Agriculture, forestry and fishery, B = Mining, C = Manufacturing, etc. Under each division, there are several *sub-divisions*. A detailed description of division, sub-division, group, and class is available on the Statistics New Zealand website (www.stats.govt.nz). We perform industry-specific analysis based on ANZSIC06 classification.

4.3.4 Variable Description

We consider three crucial firm-level financial variables to evaluate the impact of extratropical cyclones on firm financial performance. The variables are defined below.

i. Profit

Profit is the measure of firm financial performance. It is calculated as the difference between a firm's total revenue and total cost. Each firm's profit is available as a standalone variable in the AES database.

ii. Business Equity

Business Equity is another measure of a firm financial position. It shows the value of firm assets after adjusting for business liabilities. It is calculated as total assets minus total liabilities divided by the total asset. Information on total assets and total liabilities is available in the AES for every firm.

4.3.5 Sample Population

Our Sample population comprises economically significant firms (firms) operating in New Zealand with relevant industry classification codes available at the Annual Enterprise Survey. Using the unique firm identifier code, it is possible to match the financial data of a firm with a specific geographic location. There is also information if a firm has multiple locations or not. From the industrial classification used in AES, a total of 19 broad divisions of industry (A-S) can be identified. We then conveniently reorganized them into eight groups for our final analysis.

These are

i. AGRICULTURE, FORESTRY, AND FISHING (A),
ii. WHOLESALE TRADE (F),
iii. FINANCIAL AND INSURANCE SERVICES (K),
iv. CONSTRUCTION (E),
v. TRANSPORT, POSTAL, AND WAREHOUSING (I),
vi. MANUFACTURING (C),
vii. RETAIL TRADE (G), and
viii. OTHER FIRMS (B, D, H, J, L, M, N, O, P, Q, R, and S).

We also observe that forestry firm is a sub-division of the broad AGRICULTURE, FORESTRY, AND FISHING (A) industry. Forestry firms are classified as *A03 Forestry and Logging* under ANZSIC06.

Using the firm number, we have identified the firm's geographic location at the meshblock level. We then match the geographic location of a firm to identify the firms affected by extratropical cyclones, floods, and wildfires. We utilized *geo_meshblock_code* from *dbo.load.lbf.fact.business* datable available at LBD to select the firm’s single geographical unit location where the actual production takes place. The meshblock identification process enables us to locate firms at their single geographic location at the establishment or plant level. We further identified firms with multiple locations using the AES multiple geographic indicators. We assume that estimating the impact of the extratropical cyclone, flood, and wildfire on firms with multiple geographic locations will lead us to understate the impacts of the extreme events. The understated impact is because the balance sheet figure of the multiple-location firm is calculated by aggregating the financial outcomes of its affected and unaffected units. In that case, the financial outcome of the unaffected units of the firm added to the overall balance sheet figure minimizes the real impact of the extreme events. Besides, the problem for firms with multiple locations is that we have limited information about their multiple locations. That location might only be the headquarters, their accounts team's office, or even a PO Box. In addition, for multiple-location firms, we do not know which part of their activity (profits, etc.) was done in each location (even if we know where they have additional facilities). Therefore, we cannot really examine multi-location firms. Therefore, we drop any multiple-location firms and keep only single geographic location firms situated in the affected area to show the true impacts of the extratropical cyclone, flood, and wildfire on the affected firms.

4.3.6 Estimating the Impact of Extratropical Cyclones on Firms' Financial Performance

4.3.6.1 Extratropical Cyclones Location Identification Strategy

New Zealand experienced the landfall of 16 extratropical cyclones between 1996 and 2020. Among them, 6 extratropical cyclones occurred during the period from 2010 to 2020. They are Extratropical Cyclone Gita (20-2-2018), Extratropical Cyclone Fehi (01-2-2018), Extratropical Cyclone Cook (11-04-2017), Extratropical Cyclone Debbie (3-4-2017), Extratropical Cyclone Pam (15-3-2015) and Extratropical Cyclone Lusi (14-3-2014). The cost of natural disasters (inflation-adjusted to 2017) reported by the Insurance Council of New Zealand indicates that extratropical cyclones Gita and Fehi caused around NZD35.57 million and NZD45.93 million in insurance losses in 2018, respectively. Besides, the amount of insured loss for extratropical cyclone Cook and Debbie reached NZD17.21 million and NZD91.47 million in 2017, respectively. However, extratropical cyclone Pam caused around NZD2.17 million, and extratropical cyclone Lusi was responsible for NZD3.59 million in insured losses in 2015 and 2014, respectively.

The four extratropical cyclones (Gita, Fehi, Cook, and Debbie) that occurred in 2017 and 2018 caused around NZD200 million in private insurance claims and over 17,630 weather-related public insurance claims. On the other hand, the insured losses caused by extratropical cyclones Pam and Lusi were below NZD6 million, and only 1,804 weather-related public insurance claims. Besides, we found no evidence of extratropical cyclones Pam and Lusi affected areas in the Historical Weather Events Catalogue (HWE) of the National Institute of Water and

Atmospheric Research (NIWA) as well as at least two weather-related insurance claims from a meshblock based on the Earthquake Commission (EQC)'s database. Hence, we select the economically significant four cyclones (Gita, Fehi, Cook, and Debbie) to evaluate the impact of extratropical cyclones on the financial performance of firms operating the cyclone-affected areas.

We use the Earthquake Commission (EQC)'s weather-related insurance claims and the Historical Weather Events Catalogue (HWE) of the National Institute of Water and Atmospheric Research (NIWA) to identify the extratropical cyclone-affected area. Historical Weather Events Catalogue (HWE) lists all the disaster events in New Zealand, including extratropical cyclones and the geographic location of the respective disaster. By utilizing the geographic location, we identified 17 extratropical cyclone-affected meshblocks. Additionally, we also adopt 222 extratropical cyclone-affected meshblocks already identified from the Earthquake Commission (EQC)'s weather-related insurance claims. See Roy et al. (2022) for further details on the extratropical cyclone-affected meshblocks identification process. Finally, we have a total of 239 extratropical cyclone-affected meshblocks, shown in Appendix Figure 4.1.

The firm-level financial data in the AES is provided for each financial tax year from 1st April to 31st March. Although the chosen four extratropical cyclones occurred between the calendar years between 2017 and 2018, they conveniently fall within the financial tax year 2018 (1st April 2017 to 31st March 2018).

4.3.6.2 Floods Location Identification Strategy

We identified 55 flood events that occurred between April 2000 and March 2020 from the published list of the Insurance Council of New Zealand, along with the insurance claims payment due to damages resulting from these events (ICNZ, 2021). We then selected 17 financially significant flood events by considering an arbitrary threshold of insurance loss of at least NZD10 million (inflation-adjusted to 2017) per flood event. We dropped the 2018 Flood event due to the absence of flood-affected locations in the Historic Weather Events Catalogue (HWE). Besides, 2020 Flood events were omitted to exclude the COVID19-affected years from the analysis, and the firm financial data required to estimate the 2020 Flood impacts were unavailable in the Longitudinal Business Database (LBD) at the time of data analysis of this research. We also skipped the 2000 Flood due to the unavailability of firm financial data in the LBD before 2000. Finally, we had 13 flood events for the study (Appendix Table 19).

Among the flood events, two major floods occurred in 2017. One flood hit a different part of the North Island, including Waikato, Auckland, and Northland, on March 7-13, 2017. The total insurance claim payment caused by the floods reached NZD 61.7 million (NZD 37 million for house & contents and NZD 20 million for commercial damage claims). Another flood occurred in Otago and Canterbury regions on South Island from July 20 to 22 in the same year. A total of NZD 31.2 million was paid as insurance claims due to the flood, mainly for house and contents damage claims (NZD 18 million). A severe flood happened in West Coast and Tasman-Nelson regions On March 23-24, 2016. Franz Josef of the West Coast and Motueka and Riwaka of the Tasman-Nelson areas were the worst flooded regions. Out of the total NZD 30.2 million insurance claim payment for the flood, around NZD 27 million was paid to the commercial sector. Another major flood hit the Dunedin City of Otago and the rural areas in Nelson on June 2-4, 2015, resulting in a total of NZD 28.2 million in insurance claim payments, mainly to flood-affected residents (NZD 18 million). Another major flood event occurred in the lower North Island in the same year, especially in Wanganui and Wellington regions. Residential and commercial sectors made 1,766 and 657 insurance claims after the floods. The flood caused an insurance claim payment of NZD 41.5 million. One of the costliest flood events occurred in the Tasman-Nelson and Otago regions during April 17-18, 2014. The outcomes of the flood were damage to houses, contents, commercial properties, and motor vehicles. The number of insurance claims from the residential and commercial sectors was 7,189 and 1,923, respectively. The total insurance claims payment reached NZD 55.3 million. Out of the total payment, around NZD 29 million was paid to the residential sector alone. Heavy rain brought by a lower pressure system caused severe flooding in parts of the Bay of Plenty, Tasman-Nelson, and Waikato regions on April 19-22, 2013. The flood resulted in an insurance payment of NZD 46.2 million. Similarly, floods in 2011, 2010, 2005, 2004, and 2002 also caused widespread damage to property and infrastructure and insurance claims payment. We utilize data from the Historic Weather Events Catalogue (HWE) of the National Institute of Water and Atmospheric Research (NIWA) to locate the flood-affected geographic location. Based on the geographic location, we identified 60 flood-affected meshblocks[6] across the country (Appendix Figure 4.4).

4.3.6.3 Wildfires Location Identification Strategy

The identification process of the wildfire-affected New Zealand Forests area location has been accomplished in a few steps. At the initial stage, the Land Use Carbon Analysis (LUCAS) land use map version 8 from the New Zealand Ministry for the Environment[7] was used to identify the 12 land uses, including forest land. After that, the Terra and Aqua combined Moderate Resolution Imaging Spectroradiometer (MODIS) Land Cover Type data product (MCD12Q1), version 6, and the International Geosphere-Biosphere Programme (IGBP) classification scheme were utilized to determine the evergreen forest. Following Qin et al. (2019) and Rogers et al. (2015), the MODIS-derived MCD64A1 product, version 6, was used to locate the burned and non-burned land surfaces with a daily 500m spatial resolution. The fire start and end dates have been calculated by subtracting the date uncertainty (given in number of days) to fire date and adding the date uncertainty to the fire, respectively.

We identified 47 wildfire events in New Zealand from 2001 to 2017. Using the geographic coordinates provided for each fire event in the database, we identify the 65 meshblocks of wildfire incidents. Among them, we found fourteen wildfires affected meshblocks in 2001, one meshblock in 2002, four meshblocks in 2003, two meshblocks in 2004, one meshblock in 2006, three meshblocks in 2007, three meshblocks in 2008, two meshblocks in 2010, four meshblocks in 2012, ten meshblocks in 2013, one meshblock in 2014, six meshblocks in 2016, fourteen meshblocks in 2017. The wildfire-affected meshblocks have been shown in (Appendix Figure 4.9).

4.3.6.4 Estimation Methods

We use an econometric approach to estimate the impact of extratropical cyclones, floods and wildfires on firm profit and a balance sheet variable, business equity. We assume that a firm's profitability is influenced by time-invariant unobserved heterogeneous factors, including firm management skills, geographic location, etc. We also assume that firm profitability might be

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[6] A meshblock is the smallest geographic unit for which statistical data is collected and processed by Statistics New Zealand.

[7] Available for download at https://data.mfe.govt.nz/layer/52375-lucas-nz-land-use-map-1990-2008-2012-2016-v008/.

influenced by time-varying factors related to overall economic variation. We estimate a firm fixed-effects panel regression model including the year fixed effects to control for firm-level time-invariant unobserved factors and time-varying determinants affecting the firm's profitability. The regression equations we estimate are as follows in Equation 1-3.

$$Y_{it}^{d} = \sum_{\tau=t-2}^{t+2} \beta_\tau Cyclone_{i\tau} + \lambda_t + \mu_i + \varepsilon_{it} \qquad (1)$$

$$Y_{it}^{d} = \sum_{\tau=t-2}^{t+2} \delta_\tau Flood_{i\tau} + \gamma_t + \theta_i + \varepsilon_{it} \qquad (2)$$

$$Y_{it}^{d} = \sum_{\tau=t-2}^{t+2} \emptyset_\tau Fire_{i\tau} + \varphi_t + \sigma_i + \varepsilon_{it} \qquad (3)$$

Here, the dependent variable Y_{it}^{d} shows the firm financial variable under category *d* (profit and business equity) expressed in absolute value at time *t* year by firm *i*. In Equation 1, $Cyclone_{i\tau}$ indicates extratropical cyclone-affected meshblocks, and β_τ shows the coefficients of the cyclone-affected firms' profit and business equity. More specifically, $Cyclone_{it} = 1$ for the firms located in the cyclone-affected meshblocks during the cyclone year in 2018 and $Cyclone_{it-1} = 1$ for the same firms in the one the lag year in 2017. Similarly, $Cyclone_{it+1} = 1$ for the same firms observed in the one the lead year in 2019. In Equation 2, flood-affected meshblocks are indicated by $Flood_{i\tau}$ and δ_τ shows the coefficient of the flood-affected firm's profit and business equity. For instance, $Flood_{it} = 1$ for the firms located in the flood-affected meshblocks during the flood year, whereas $Flood_{it+1} = 1$ for the same firms observed the following year immediately. Similarly, $Flood_{it-1} = 1$ for the same firms in the lag of one year. In the same way, in Equation 3, wildfires affected meshblocks are indicated by $Fire_{i\tau}$ and $\emptyset_\tau$ shows the coefficients of the wildfires affected the forestry firm's profit and business equity. For example, $Fire_{it} = 1$ for the forestry firms located in the wildfire-affected meshblocks during the wildfire's year and zero otherwise. Similarly, $Fire_{it-1} = 1$ for the same firms in the lag of one year and zero otherwise. λ_t captures the year-fixed effect from 2011 to 2020 for Equation 1, and the year-fixed effect from 2001 to 2020 is indicated by γ_t for Equation 2 and φ_t for Equation 3. μ_i, θ_i, and σ_i control for firm fixed effects in Equations 1-3, respectively. Finally, ε_{it} is an idiosyncratic error term (ε_{it} *i.i.d*). The regression models (1)-(3) consider only two periods after cyclones, floods, and wildfires: (t+1) and (t+2), respectively. Initially, we estimated also the coefficient for (t+3) for all regression specifications but found no statistically significant results. Therefore, (t+3) was omitted from the final models we present.

We assume that standard errors are correlated within firms, not across the firms. So, we calculate the clustered standard errors at the firm level to adjust for heteroscedasticity and correlation that may occur within the firm over time (Stock & Watson, 2020).

4.4 RESULTS AND DISCUSSION

4.4.1 Impact of Extratropical Cyclones on Firms' Financial Performance

4.4.1.1 Summary Statistics

Table 1 provides summary statistics of profit, and Appendix Table 4.2 presents summary statistics of business equity of different firms affected by extratropical cyclones along with control firms in 2018 and 2019, respectively. We keep the summary statistics table of the firm's profit in the text as the primary purpose of the study was to investigate the impact of extratropical cyclones on firms' profit level. On the other hand, business equity represents the firms' financial position; hence we put the table in the Appendix. Columns 1 and 3 show that the mean, standard deviation, and observations of extratropical cyclones affected firms, and Columns 2 and 4 outline the mean, standard deviation, and observations of the remaining unaffected firms. It has been seen that the average profit and business equity of extratropical cyclone-affected and unaffected firms vary depending on the type of industry during 2018 and 2019. For instance, average profit increased for firms in all industries except wholesale trading firms located in the extratropical cyclone-affected meshblocks from 2018 to 2019. On average, the business equity of all firms except financial and insurance and transport decreased during the same time (Appendix Table 4.2). The changes in the number of firms in treatment and control meshblocks might lead to the issue of sample attrition in the data. We believe the changes are random due to AES's sampling process and not related to the extratropical cyclones from 2018 to 2019. A total of 267 out of 2,070 firms were absent in AES 2019. However, 33 out of 267 firms (absent in AES 2019) reappeared in the survey data in AES 2020. Therefore, we argue that the decrease in the firms' number after cyclones was not because of the firms ceasing their operation but because they either did not respond to the survey questionnaire or were dropped during the AES survey.

4.4.1.2 Estimation Results

The section presents the regression results of the estimated impact of extratropical cyclones on the profit level of firms situated in the cyclone-affected areas compared with the unaffected areas. In the text, we show a 95 percent confidence interval graph of the estimated profit coefficients and provide a detailed regression results table for each firm category in the Appendix. We estimate Equation 1 for profit and business equity in absolute value and the standardized regression coefficients (zero mean and one standard deviation). The reason for estimating standardized regression is to show the relative strength of the explanatory variables on the dependent variable as well as compare the relative impact of extratropical cyclones across the firms.

4.4.1.3 Impact of Extratropical Cyclone on Firms' Profit Level

Figure 1 presents the estimated regression coefficients of firms' profit with a 95 percent confidence interval showing the impact of extratropical cyclones on firms' annual profit expressed in the New Zealand Dollar. The estimated regression coefficient of the dummy variable ($Cyclone_{it}$) in Column 1 in Appendix Table 3 is -43.34 and statistically significant at a 5 percent level. It indicates that, after controlling for firm-level time-invariant fixed-effects, on average, profit-level decreased by NZD43.34 thousand for the firms in Agriculture, forestry, and fishing industry in the extratropical cyclone areas compared to firms not located in the same areas in 2018. The estimated coefficients before and after 2018 are statistically insignificant, indicating no significant changes in profit before and after the occurrence of the cyclone in 2018, which is also visible in Figure 1. The estimated profit coefficients ($Cyclone_{it}$) of wholesale trade firms in Column 1 at Appendix Table 4 is -221.5 and statistically significant at 5 percent. The results indicate that firms engaged in wholesale trade in the cyclone-affected areas faced, on average, NZD221.5 thousand profit decline in 2018.

The adverse impact of extratropical cyclones on the annual profit level of firms in the financial and insurance services industry is larger than the other firms. From Column 1 of Appendix Table 5, it is seen that the estimated coefficient of $Cyclone_{it}$ is -1,404 and statistically significant at a 1 percent level. It can be interpreted that, on average, financial and insurance services firms in the extratropical cyclones affected area experienced a profit loss of NZD1,404 thousand compared with similar firms outside the affected area in 2018 after controlling for firm-level time-invariant fixed effects. Besides, the loss of annual profit continued in the subsequent year and amounted to NZD1,268 thousand in 2019 as the estimated coefficient of $Cyclone_{it}$ is -1,268 and statistically significant at a 5 percent level. The severe impact of cyclones on this sector might be influenced by further profit reduction due to insurance payouts by these disaster-affected insurance firms. The trend of profit decline is also visible in Figure 1. We find no statistical evidence of the change in annual profit of the extratropical cyclones affecting firms in the construction industry (Appendix Table 6).

Table 4.1: Summary Statistics Extratropical Cyclone-Affected Firms' Profit

		2018		2019	
		Affected by Extratropical Cyclone in 2018) (1)	Control Meshblocks (2)	Affected by Extratropical Cyclone in 2018) (3)	Control Meshblocks (4)
Agriculture					
	Mean	50.37	135.38	50.63	97.53
	Std. Dev.	190.04	4,525.43	203.64	2,116.77
	Observations	354	69,810	315	67,692
Wholesale Trade					
	Mean	21.55	253.37	16.46	270.72
	Std. Dev.	82.44	2,388.90	252.18	2,610.26
	Observations	60	16,077	48	15,771
Financial and Insurance					
	Mean	126.70	2458.37	136.19	2586.33
	Std. Dev.	309.45	58606.85	302.22	50999.48
	Observations	78	14,019	72	11,487
Construction					
	Mean	35.76	54.66	81.56	65.87
	Std. Dev.	203.53	3,138.36	416.73	1,618.19
	Observations	288	57,708	246	59,841
Transport					
	Mean	52.96	203.42	73.27	202.52
	Std. Dev.	124.20	5,921.30	157.78	6,203.49
	Observations	51	14,334	45	14,643
Manufacturing					
	Mean	-4.90	329.35	52.33	419.03
	Std. Dev.	721.53	5,358.42	158.84	10,543.58
	Observations	90	20718	78	20,115
Retail Trade					
	Mean	25.71	98.39	92.16	117.22
	Std. Dev.	123.66	1,927.60	455.97	2,250.71
	Observations	90	25,029	72	25,383
Other Firms					
	Mean	93.11	117.93	114.71	127.55
	Std. Dev.	721.61	5167.97	852.63	3839.54
	Observations	1,014	205,950	981	218,514

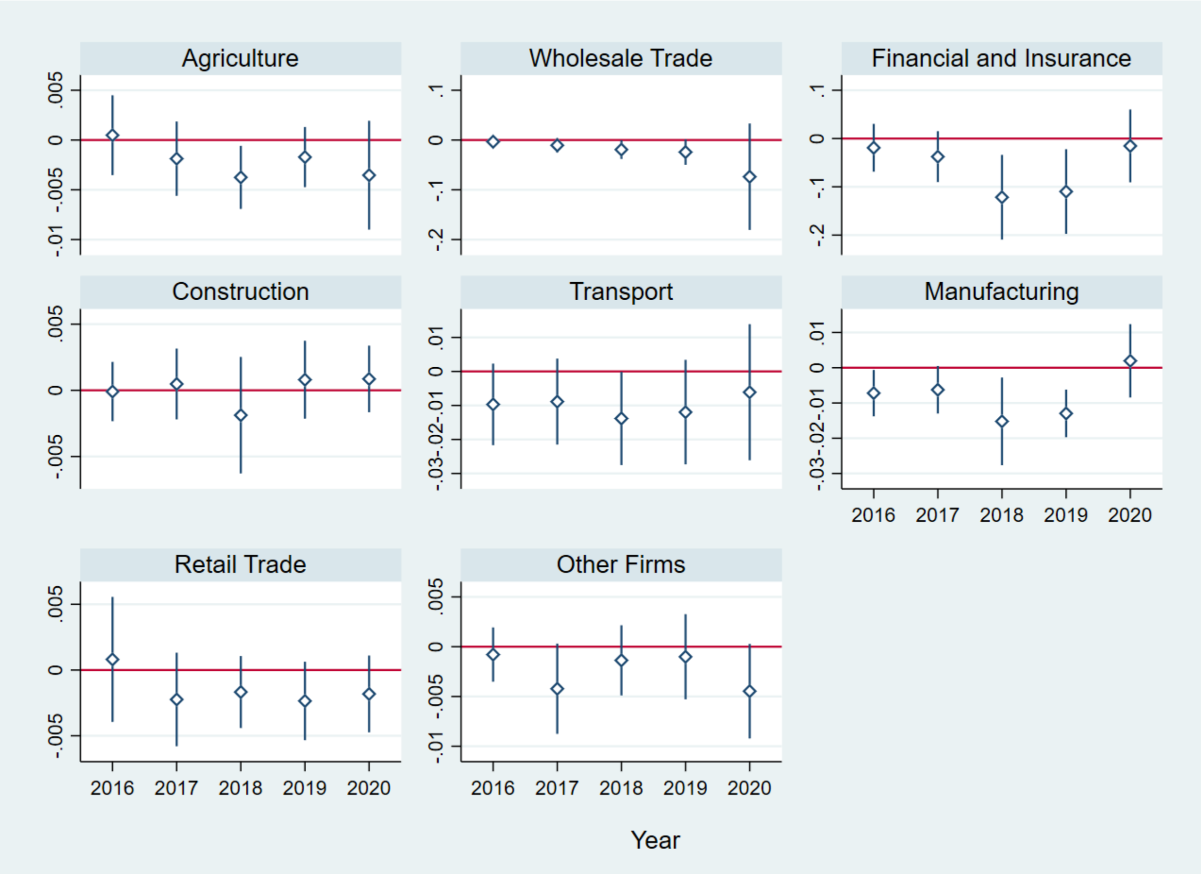
Note: Figures are expressed in New Zealand Dollars (in Thousands). Due to changes in Statistical Classification for Institutional Sectors (SCIS), around 10,000 family trusts units were included in the AES 2018. Therefore, we exclude these trust units from the control in 2019.

Figure 4.1: Extratropical Cyclones Impact on Firms' Profit (Absolute Coefficient)

Note: The figures indicate the point estimates of the impact of extratropical cyclones (occurred during FY2018) on firms' profit by using the specification in Equation 1. Regression coefficients are expressed as New Zealand Dollars in thousands. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

The extratropical cyclones also had a negative impact on the yearly profit of transport, postal, and warehousing firms in 2018. The estimated profit coefficient ($Cyclone_{it}$) in Column 1 of Appendix Table 7 is -159.8 and is statistically significant at 5 percent. The regression result implies that after adjusting for time-invariant fixed effects at the firm level, the annual profit loss incurred by the extratropical cyclones-affected firms in the transport, postal, and warehousing industry was NZD159.8 thousand in 2018. We found no statistically significant evidence of the impact of extratropical cyclones on the annual profit of the firms in the manufacturing industry (Appendix Table 8), the retail trade industry (Appendix Table 9), and the rest of the sectors (Appendix Table 10).

Figure 4.2: Extratropical Cyclones Impact on Firms' Profit (Standardized Coefficient)



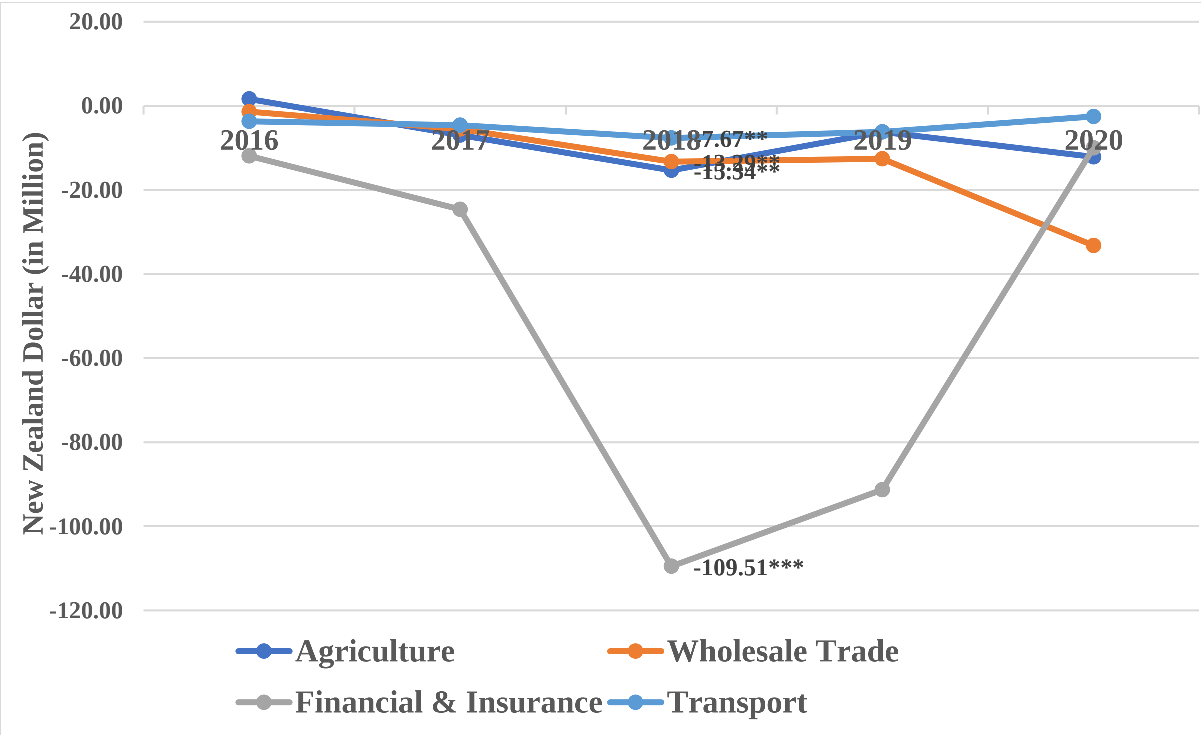
Note: The figures indicate the point estimates of the impact of extratropical cyclones (occurred during FY2018) on firms' profit by using the specification in Equation 1. Regression coefficients are expressed as standardized coefficients. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

We also estimated the standardized regression of Equation 1 to show the impact of extratropical cyclones on the annual profit of the firms using the Z-score (Figure 2). The estimated coefficient of the dummy variable ($Cyclone_{it}$) of the extratropical cyclone-affected firms in the agriculture industry in Column 1 of Appendix Table 11 is -0.00375, and it is statistically significant at a 5 percent level. The result indicates that extratropical cyclones affected firms in the agriculture industry faced a 0.00375 standard deviation decrease in annual profit than those firms unaffected during the cyclone year. Similarly, firms from the wholesale trade industry experienced a 0.0192 standard deviation decrease in annual profit in 2018 (Appendix Table 12). In addition, extratropical cyclones affected firms in the financial and insurance services industry incurred a 0.122 standard deviation and 0.110 standard deviation decrease in annual profit compared with the firms unaffected by the cyclones in the same industry during 2018 and 2019, respectively (Appendix Table 13). Similarly, the estimated standardized regression coefficient in Column 1 of Appendix Table 15 shows that the profit of extratropical cyclones affected firms in the transport, postal, and warehousing industry declines by 0.0138 standard deviations in relation to the firms in the same industry unaffected by the cyclones during 2018. On the other hand, the estimated standardized regression coefficients presented in Appendix Tables 14, 16, 17, and 18 indicate no statistically significant evidence of the impacts of extratropical cyclones on the profits of the firms in construction, manufacturing, retail trade, and the rest of the industries, respectively.

4.4.1.4 Impact of Extratropical Cyclone on Firms' Business Equity

We also examined the impact of extratropical cyclones on the firm's financial position by regressing the business equity, a balance-sheet indicator of the firm. The estimated business equity coefficients are presented with 95 percent confidence interval graphs in absolute and standardized values in Appendix 2 and 3, respectively. From the regression results presented in Appendix Figure 2 (absolute value) and Appendix Figure 3 (standardized value), it is evident that extratropical cyclones had no statistically significant effects on the business equity of firms in agriculture, wholesale trade, financial and insurance, construction, transport, manufacturing, retail trade, and other firms. The estimated coefficients of business equity of all the firms have been provided in Colum 2 of Appendix Tables 3-18, respectively.

Figure 4.3: Aggregate Firms' Profit Loss due to Extratropical Cyclones in New Zealand



Notes: These figures are the product of regression coefficients and the number of firms in affected meshblocks in the corresponding year. Firms in Retail Trade, Construction, Manufacturing and Other Sectors have not been reported in the line graph due to statistically insignificant coefficients value. Every regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. ** $p<0.05$, *** $p<0.01$.

4.4.1.5 Aggregate Profit Loss of Firms due to Extratropical Cyclones

This section provides an estimate of the aggregated annual profit loss of different extratropical cyclone-affected firms in 2018. Figure 3 shows that firms related to the agriculture, forestry, and fishing industries experienced an estimated total of NZD15.34 million loss of profit due to extratropical cyclones. The extratropical cyclone-affected firms from the wholesale trade industry incurred an estimated NZD13.29 million loss of profit caused by extratropical cyclones. The firms in the financial and insurance services industry face the largest aggregate profit loss. Overall, firms from that industry encountered a total estimated NZD109.51 million profit loss during the cyclone period. Lastly, transport, postal, and warehousing firms also lost an estimated NZD7.67 million in profit caused by extratropical cyclones.

4.4.2 Impact of Floods on Firms' Financial Performance

We also attempted to investigate the impact of floods on the firms' financial performance (profit and business equity). The summary statistics of firms' profit and business equity are presented in Appendix Table 20 and 21, respectively. It has been seen that the number of flood-affected firms in wholesale trade, financial and insurance, and transport industry was below 20. Hence, the means values are not reported due to the confidentiality rule of Stats NZ. Besides, the number of flood-affected firms in construction, manufacturing, and retail trade was around 30. The average profit and business equity of flood-affected agricultural firms declined after the floods. Appendix Figures 5 and 7 indicate the 95 percent confidence interval of estimated absolute value regression coefficients of flooded firms' profit and business equity, and standardized value regression coefficients are presented in Appendix Figures 6 and 8, respectively. The detailed estimated absolute value regression coefficients have been shown in Appendix Table 22-29, respectively.

The estimated profit and business equity coefficients of agriculture, wholesale trade, construction, transport, manufacturing, and retail trade were not statistically significant. We observe that the estimated coefficients for financial and insurance are statistically significant in the flood year. However, the number of financial and insurance firms was only 15, which made the results inconclusive regarding the flood impacts. It may also be that floods had no substantial effects on financial and insurance firms' profit and business equity. We also estimated the standardized coefficients and provided them in Appendix Tables 30-37, respectively. The findings also show that floods had no significant impact on the flood-affected firm's financial performance.

4.4.3 Impact of Wildfire on Forestry Firms' Financial Performance

This section shows the impact of wildfires on forestry firms' financial performance in terms of profit and business equity. Appendix Table 38 indicates the summary statistics of fire-affected forestry and control firms' profit and business equity. The mean value of profit and business equity has been omitted due to the small number of firms in accordance with Statistics NZ.

We show the 95 percent confidence interval estimated profit and business equity coefficients in absolute value (Appendix Figure 10) and standardized value (Appendix Figure 11). Besides, detailed regression coefficients also have been presented in Appendix Table 39 (absolute value) and Appendix Table 40 (standardized value). It has been seen that the estimated regression coefficient $Fire_{it}$ is statistically insignificant, implying no impact of wildfire on the profitability of forestry firms. We also found that wildfires had no significant effect on the business equity of the forest firms during the same time.

4.4.4 Robustness of the Results

We attempt to estimate a comprehensive regression including all disasters (cyclones, floods, and wildfires) together to check the potential correlation between cyclones and flooding and omitted variable bias. We also estimate the regression specifications considering the clustered standard error at the meshblock level for all three disaster events. Besides, another regression specification examines the disaster impacts on all businesses together to see if there is an aggregate overall effect. The purpose of estimating these different regression specifications is to show the robustness of our findings. We show the comprehensive regression results in absolute value (Appendix Table 41-48) and standard values (Appendix Table 49 - 56). The estimated regression results show that the profit level of the agriculture, financial and insurance service sectors significantly declined during the disaster period. We also observed that the business equity of the disaster-affected agriculture firms is negative and statistically significant. The profit coefficients of the other sectors are found statistically insignificant. After including all disasters, it is seen that both the agriculture and financial sectors experienced a negative impact from cyclones, floods, and wildfires.

In other specifications, we also attempted to estimate the regression equation by considering clustered standard error at the meshblock level. The estimated regression results in Appendix Table 57-64 (absolute value) and Appendix Table 65-72 (standard value) for cyclones, Appendix Table 73-80 (absolute value) and Appendix Table 81-88 (standard value) for floods, and Appendix Table 89 (absolute value) and Appendix Table 90 (standard value) for wildfires, are consistent with our initial results in every specification. We also examined the impacts of the disasters on all businesses together and presented the estimated results in Appendix Table 91-92 for cyclones and Appendix Table 93-93 for floods. It is seen that both cyclones and floods have no aggregate overall impact on all businesses operating in the cyclones- and flood-affected areas, respectively.

4.5 CONCLUSION

The present study has examined the impacts of extratropical cyclones, floods, and wildfires on the annual profit and business equity of cyclone-affected different economically significant firms operating in New Zealand. The firm-level administrative financial data have been accessed from the Annual Enterprise Survey (AES) available at Longitudinal Business Database (LBD), Statistics New Zealand. The extratropical cyclone-affected meshblocks have been identified using weather-related insurance claims data from the Earthquake Commission and Historical Weather Events Catalogue from NIWA. The flood-affected meshblocks have been identified using the Historical Weather Events Catalogue from NIWA, and a comprehensive database based on public data has been used to select the wildfire location.

The estimated results show that the annual profit of extratropical cyclone-affected agriculture, wholesale trade, financial and insurance services, and transportation firms have been negatively affected by the cyclones compared with the unaffected firms. For instance, the estimated profit loss in the agricultural firms was NZD15.34 million in the year cyclones occurred. In addition, wholesale trade and transport firms experienced an estimated profit loss of NZD13.29 million and NZD7.67 million, respectively. The financial and insurance firms faced the worst impact of the cyclones, with an estimated loss of profit amounting to NZD109.51 million in the cyclone year. The cyclones-induced firms' profit loss figure might be considered economically large enough to be meaningful. For the rest of the firms, the estimated results confirm no significant changes in profit and business equity caused by the extratropical cyclones. Besides, the estimated results show that floods had no significant impact on flood-affected firms' profit and business equity. In addition, the wildfires had no significant impact on forestry firms' profit and business equity. This research is the first attempt to assess the firm-level impact of extratropical cyclones, floods, and wildfires on firms' financial performance using the comprehensive administrative panel data from the Longitudinal Business Database (LBD). The study findings provide an in-depth insight into the microlevel impact of extratropical cyclones, floods, and wildfires on the financial performance of economically significant firms operating in New Zealand.

APPENDIX

Appendix Table 4.1: ANZSIC 2006 Industry Divisions

Code	Industry
A	Agriculture, forestry, and fishing
B	Mining
C	Manufacturing
D	Electricity, gas, water, and waste services
E	Construction
F	Wholesale trade
G	Retail trade
H	Accommodation and food services
I	Transport, postal, and warehousing
J	Information media and telecommunications
K	Financial and insurance services
L	Rental, hiring, and real estate services
M	Professional, scientific, and technical services
N	Administrative and support services
O	Public administration and safety
P	Education and training
Q	Health care and social assistance
R	Arts and recreation services
S	Other services

Source: Statistics New Zealand (2010)

Appendix Table 4.2: Summary Statistics of Extratropical Cyclone-Affected Firms' Business Equity

	2018		2019	
	Affected by Extratropical Cyclone in 2018) (1)	Control Meshblocks (2)	Affected by Extratropical Cyclone in 2018) (3)	Control Meshblocks (4)
Agriculture				
Mean	0.23	-0.03	0.16	0.01
Std. Dev.	4.68	21.36	3.17	10.11
Observations	348	67,785	309	65,631
Wholesale Trade				
Mean	-0.38	-0.70	-0.90	-0.53
Std. Dev.	2.97	12.71	5.49	9.65
Observations	54	15,546	42	15,189
Financial and Insurance				
Mean	0.16	-0.33	0.23	-0.44
Std. Dev.	3.12	15.57	1.75	15.02
Observations	78	13,188	69	10,767
Construction				
Mean	0.12	-0.13	0.08	-0.28
Std. Dev.	1.19	5.78	1.45	29.85
Observations	270	54,783	231	56,808
Transport				
Mean	-0.14	-0.97	0.41	9.65
Std. Dev.	3.21	112.34	0.44	4.29
Observations	45	13,158	39	13,413
Manufacturing				
Mean	0.15	-0.39	0.08	-0.49
Std. Dev.	0.82	12.73	1.06	13.82
Observations	87	20,013	75	19,365

Retail Trade					
	Mean	-0.27	-0.64	-1.11	-0.70
	Std. Dev.	3.45	11.21	5.06	10.79
	Observations	90	24,258	69	24,183
Other Firms					
	Mean	-0.08	-0.43	-0.12	-0.4
	Std. Dev.	3.83	26.49	5.36	27.36
	Observations	951	192,453	828	203,838

Note: Figures are expressed in New Zealand Dollars (in Thousands). Due to changes in Statistical Classification for Institutional Sectors (SCIS), around 10,000 family trusts units were included in the AES 2018. Therefore, we exclude these trust units from the control in 2019.

Appendix Table 4.3: Impact of Extratropical Cyclones on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	5.613	9.162
	(23.64)	(5.990)
$Cyclone_{it-1}$	-21.62	15.66
	(22.00)	(10.23)
$Cyclone_{it}$	-43.34**	2.719
	(18.67)	(2.689)
$Cyclone_{it+1}$	-19.78	0.937
	(17.81)	(3.487)
$Cyclone_{it+2}$	-40.81	2.735
	(32.22)	(2.660)
R^2 (within)	0.0002	0.000
R^2 (between)	0.000	0.000
Number of firms	117,135	115,122
Total of observations	700,833	678,123

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.4: Impact of Extratropical Cyclones on Financial Indicators of Wholesale Trading Firms (F)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-38.58	9.42
	(48.62)	(5.459)
$Cyclone_{it-1}$	-122.9	129.1
	(86.08)	(82.06)
$Cyclone_{it}$	-221.5**	39.50
	(110.7)	(25.02)
$Cyclone_{it+1}$	-279.4	37.62
	(150.9)	(24.50)
$Cyclone_{it+2}$	-851.8	38.11
	(630.0)	(24.28)
R^2 (within)	0.0001	0.0002
R^2 (between)	0.0000	0.0001
Number of firms	32,328	31,644
Total of observations	138,822	133,761

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.5: Impact of Extratropical Cyclones on Financial Indicators of Financial and Insurance Services Firms (K)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-220.9	380.3
	(291.6)	(356.1)
$Cyclone_{it-1}$	-432.5	103.7
	(310.5)	(96.70)
$Cyclone_{it}$	-1,404***	95.19
	(517.0)	(93.55)
$Cyclone_{it+1}$	-1,268**	97.80
	(516.8)	(93.40)
$Cyclone_{it+2}$	-175.9	92.04
	(444.8)	(89.71)
R^2 (within)	0.0004	0.0001
R^2 (between)	0.0000	0.0001
Number of firms	35,280	33,846
Total of observations	119,010	111,654

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.6: Impact of Extratropical Cyclones on Financial Indicators of Construction Firms (E)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-1.099	18.88
	(13.20)	(15.69)
$Cyclone_{it-1}$	5.525	17.97
	(15.77)	(10.87)
$Cyclone_{it}$	-21.74	6.460
	(25.95)	(4.548)
$Cyclone_{it+1}$	9.242	6.516
	(17.35)	(4.279)
$Cyclone_{it+2}$	9.921	2.387
	(14.84)	(4.366)
R^2 (within)	0.0001	0.0001
R^2 (between)	0.0001	0.0000
Number of firms	114,612	111,363
Total of observations	450,054	423,963

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.7: Impact of Extratropical Cyclones on Financial Indicators of Transport, Postal, and Warehousing Firms (I)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-112.0	1.756
	(70.65)	(1.645)
$Cyclone_{it-1}$	-102.5	2.909
	(74.47)	(2.057)
$Cyclone_{it}$	-159.8**	1.738
	(80.81)	(2.153)
$Cyclone_{it+1}$	-138.3	0.704
	(90.55)	(1.574)
$Cyclone_{it+2}$	-70.57	1.320
	(117.9)	(1.853)
R^2 (within)	0.0002	0.0004
R^2 (between)	0.0000	0.0000
Number of firms	31,716	30,348
Total of observations	126,858	115,713

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.8: Impact of Extratropical Cyclones on Financial Indicators of Manufacturing Firms (C)

	Profit (1)	Business Equity (2)
$Cyclone_{it-2}$	-83.34**	4.561
	(38.78)	(4.462)
$Cyclone_{it-1}$	-72.26	5.751
	(39.74)	(7.770)
$Cyclone_{it}$	-175.8**	-0.810
	(73.34)	(3.072)
$Cyclone_{it+1}$	-149.7***	-1.046
	(39.76)	(3.136)
$Cyclone_{it+2}$	22.63	-1.332
	(61.33)	(3.106)
R^2 (within)	0.0003	0.0001
R^2 (between)	0.0004	0.0002
Number of firms	40,383	39,555
Total of observations	196,656	189,495

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.9: Impact of Extratropical Cyclones on Financial Indicators of Retail Trade Firms (G)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	9.338	23.44
	(28.01)	(51.31)
$Cyclone_{it-1}$	-25.85	12.67
	(20.97)	(13.48)
$Cyclone_{it}$	-19.31	7.364
	(16.14)	(9.092)
$Cyclone_{it+1}$	-27.16	-26.23
	(17.58)	(26.91)
$Cyclone_{it+2}$	-20.99	-9.792
	(17.21)	(10.04)
R^2 (within)	0.001	0.0001
R^2 (between)	0.0001	0.0000
Number of firms	55,437	53,907
Total of observations	219,594	209,124

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.10: Impact of Extratropical Cyclones on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-9.142	0.0624
	(16.07)	(11.77)
$Cyclone_{it-1}$	-48.80	6.198
	(26.73)	(5.914)
$Cyclone_{it}$	-15.83	-1.709
	(20.76)	(3.887)
$Cyclone_{it+1}$	-11.66	-0.221
	(25.22)	(4.238)
$Cyclone_{it+2}$	-51.64	-1.838
	(28.00)	(3.883)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	430,845	413,385
Total of observations	1,840,890	1,716,303

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.11: Impact of Extratropical Cyclones on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A) (Standardized Coefficients)

	Profit	Business Equity
	(1)	**(2)**
$Cyclone_{it-2}$	0.000486	0.00271
	(0.00205)	(0.00177)
$Cyclone_{it-1}$	-0.00187	0.00464
	(0.00190)	(0.00303)
$Cyclone_{it}$	-0.00375**	0.000806
	(0.00162)	(0.000797)
$Cyclone_{it+1}$	-0.00171	0.000278
	(0.00154)	(0.00103)
$Cyclone_{it+2}$	-0.00353	0.000810
	(0.00279)	(0.000788)
R^2 (within)	0.0002	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	117,135	115,122
Total of observations	700,833	678,123

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.12: Impact of Extratropical Cyclones on Financial Indicators of Wholesale Trading Firms (F) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-0.00334	0.00279
	(0.00421)	(0.00162)
$Cyclone_{it-1}$	-0.0106	0.0382
	(0.00745)	(0.0243)
$Cyclone_{it}$	-0.0192**	0.0117
	(0.00958)	(0.00741)
$Cyclone_{it+1}$	-0.0242	0.0111
	(0.0131)	(0.00726)
$Cyclone_{it+2}$	-0.0737	0.0113
	(0.0545)	(0.00719)
R^2 (within)	0.0001	0.0002
R^2 (between)	0.0000	0.0001
Number of firms	32,328	31,644
Total of observations	138,822	133,761

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.13: Impact of Extratropical Cyclones on Financial Indicators of Financial and Insurance Services Firms (K) (Standardized Coefficients)

	Profit	Business Equity
	(1)	**(2)**
$Cyclone_{it-2}$	-0.0191	0.113
	(0.0252)	(0.105)
$Cyclone_{it-1}$	-0.0374	0.0307
	(0.0269)	(0.0287)
$Cyclone_{it}$	-0.122***	0.0282
	(0.0448)	(0.0277)
$Cyclone_{it+1}$	-0.110**	0.0290
	(0.0447)	(0.0277)
$Cyclone_{it+2}$	-0.0152	0.0273
	(0.0385)	(0.0266)
R^2 (within)	0.0004	0.0001
R^2 (between)	0.0000	0.0001
Number of firms	35,280	33,846
Total of observations	119,010	111,654

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.14: Impact of Extratropical Cyclones on Financial Indicators of Construction Firms (E) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-9.51e-05	0.00559
	(0.00114)	(0.00465)
$Cyclone_{it-1}$	0.000478	0.00532
	(0.00136)	(0.00322)
$Cyclone_{it}$	-0.00188	0.00191
	(0.00225)	(0.00135)
$Cyclone_{it+1}$	0.000800	0.00193
	(0.00150)	(0.00127)
$Cyclone_{it+2}$	0.000859	0.000707
	(0.00128)	(0.00129)
R^2 (within)	0.0001	0.0001
R^2 (between)	0.0001	0.0000
Number of firms	114,612	111,363
Total of observations	450,054	423,963

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.15: Impact of Extratropical Cyclones on Financial Indicators of Transport, Postal, and Warehousing Firms (I) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.00970	0.000520
	(0.00612)	(0.000487)
$Cyclone_{it-1}$	-0.00887	0.000862
	(0.00645)	(0.000610)
$Cyclone_{it}$	-0.0138**	0.000515
	(0.00699)	(0.000638)
$Cyclone_{it+1}$	-0.0120	0.000208
	(0.00784)	(0.000466)
$Cyclone_{it+2}$	-0.00611	0.000391
	(0.0102)	(0.000549)
R^2 (within)	0.0002	0.0004
R^2 (between)	0.0000	0.0000
Number of firms	31,716	30,348
Total of observations	126,858	115,713

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.16: Impact of Extratropical Cyclones on Financial Indicators of Manufacturing Firms (C) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-0.00721**	0.00135
	(0.00336)	(0.00132)
$Cyclone_{it-1}$	-0.00626	0.00170
	(0.00344)	(0.00230)
$Cyclone_{it}$	-0.0152**	-0.000240
	(0.00635)	(0.000910)
$Cyclone_{it+1}$	-0.0130***	-0.000310
	(0.00344)	(0.000929)
$Cyclone_{it+2}$	0.00196	-0.000395
	(0.00531)	(0.000920)
R^2 (within)	0.0003	0.0001
R^2 (between)	0.0004	0.0002
Number of firms	40,383	39,555
Total of observations	196,656	189,495

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.17: Impact of Extratropical Cyclones on Financial Indicators of Retail Trade Firms (G) (Standardized Coefficients)

	Profit	Business Equity
	(1)	**(2)**
$Cyclone_{it-2}$	0.000808	0.00694
	(0.00242)	(0.0152)
$Cyclone_{it-1}$	-0.00224	0.00375
	(0.00181)	(0.00399)
$Cyclone_{it}$	-0.00167	0.00218
	(0.00140)	(0.00269)
$Cyclone_{it+1}$	-0.00235	-0.00777
	(0.00152)	(0.00797)
$Cyclone_{it+2}$	-0.00182	-0.00290
	(0.00149)	(0.00297)
R^2 (within)	0.001	0.0000
R^2 (between)	0.000	0.0000
Number of firms	55,437	53,907
Total of observations	219,594	209,124

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.18: Impact of Extratropical Cyclones on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.000791	1.85e-05
	(0.00139)	(0.00349)
$Cyclone_{it-1}$	-0.00422	0.00184
	(0.00231)	(0.00175)
$Cyclone_{it}$	-0.00137	-0.000506
	(0.00180)	(0.00115)
$Cyclone_{it+1}$	-0.00101	-6.54e-05
	(0.00218)	(0.00126)
$Cyclone_{it+2}$	-0.00447	-0.000545
	(0.00242)	(0.00115)
R^2 (within)	0.0000	0.000
R^2 (between)	0.0000	0.000
Number of firms	430,845	413,385
Total of observations	1,840,890	1,716,303

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.19: List of the Major Floods in New Zealand

Flood Year	Flood Description
2017	*Upper North Island flooding* **Date:** March 7-13, 2017 **Affected Area:** Coromandel Peninsula and Kaiaua at Waikato, New Lynn, Hunua Ranges, and Clevedon from Auckland, Kerikeri and Kaitaia from Northland. **Insured Claim Loss:** NZD 61.7 million *South Island flooding* **Date:** July 20-22, 2017 **Affected Area:** Dunedin city, Canterbury, Timaru, and Christchurch. **Insured Claim Loss:** NZD 31.2 million
2016	*Flooding and Wind - North and South Islands* **Date:** March 23-24, 2016 **Affected Area:** Franz Josef of the West Coast and Motueka and Riwaka of the Tasman-Nelson regions. **Insured Claim Loss:** NZD 30.2 million
2015	*Flooding and Storm – Otago* **Date:** June 2-4, 2015 **Affected Area:** Dunedin City and Otago. Nelson and Cable Bay. **Insured Claim Loss:** NZD 28.2 million *Flooding and Storm Lower North Island, including Whanganui* **Date:** June 18-21, 2015 **Affected Area:** Wanganui, Koitiata, Waitotara, Marton, and Whangaehu from Manawatu-Wanganui, Levin and Hutt Vally from Wellington, Hokitika from West Coast, and Golden Bay from the Tasman-Nelson region. **Insured Claim Loss:** NZD 41.5 million

2014	*Easter Weekend Storm and Floods* **Date:** April 17-19, 2014 **Affected Area:** Takaka Hill of Tasman-Nelson, Otago, and Five Fork of Otago. Bay of Plenty. **Insured Claim Loss:** NZD 55.3 million
2013	*Nelson/Bay of Plenty storm and floods* **Date:** April 19-22, 2013 **Affected Area:** Tauranga from the Bay of Plenty, Stoke and Richmond from Tasman-Nelson, and Hamilton from Waikato. **Insured Claim Loss:** NZD 46.2 million
2011	*Storm/Flooding Bay of Plenty to Northland* **Date:** January 28-29, 2011 **Affected Area:** Paihia and Pipiwai from Northland, Auckland City from Auckland, and Tauranga from the Bay of Plenty. **Insured Claim Loss:** NZD 19.8 million *Nelson Floods* **Date:** December 15-16, 2011 **Affected Area:** Richmond, Pohara, Cable Bay, and Golden Bay in the Tasman-Nelson region. **Insured Claim Loss:** NZD 16.8 million
2010	*Flooding - Northland/Coromandel/Eastern BOP* **Date:** June 1, 2010 **Affected Area:** Auckland City from Auckland, Whenuakite of Waikato, Whakatane, Edgecumbe, Matata, Opotiki, and Mount Maunganui from the Bay of Plenty. **Insured Claim Loss:** NZD 12.5 million

2005	*Flooding - BOP Tauranga / Matata* **Date:** May 18, 2005 **Affected Area:** Whangamata, Opoutere and Pauanu from Waikato, Pongakawa, Awakaponga, Edgecumbe, Matata, Papamoa, Mount Maunganui and Welcome Bay from Bay of Plenty. **Insured Claim Loss:** NZD 28.5 million
2004	*Eastern Bay of Plenty Floods* **Date:** July 17-19, 2004 **Affected Area:** Whakatane and Opotiki Districts **Insured Claim Loss:** NZD 17.6 million
2002	*North Island Flooding / Storm Damage* **Date:** June 21, 2002 **Affected Area:** Hikurangi, Kaitaia, Kawakawa, Mangkahia River Catchment, Maungaturoto, Moerewa, Otiria, Paihia, Taheke, Tangiteroria, Tangowahire, Wahue, Whangarei Heads, from Northland, Port Charles Tararu, Tepuru and Tirau from Waikato, Mamaku from Bay of Plenty **Insured Claim Loss:** NZD 21.5 million

Source: Insurance Council of New Zealand (ICNZ, 2021) and NIWA (2021b)

Appendix Table 4.20: Summary Statistics of Flood-Affected Firms' Profit

	Flooded Firms			Control Firms
	Before Floods (1)	During Floods (2)	After Floods (3)	During Floods (4)
Agriculture				
Mean	25.18	43.34	23.77	56.14
Std. Dev.	500.54	89.8	90.54	3,111.73
Observations	222	246	228	1,456,632
Wholesale Trade				
Mean	S	S	S	266.11
Std. Dev.	709.56	1241.69	58.13	15,985.5
Observations	6	12	9	201,483
Financial and Insurance				
Mean	S	S	S	1,529.76
Std. Dev.	382.9	278.07	411.44	39,343.22
Observations	15	15	12	231,525
Construction				
Mean	-34.14	-43.63	38.22	52.62
Std. Dev.	243.3	389.12	84.87	1,482.08
Observations	24	27	24	720,102
Transport				
Mean	S	S	S	132.32
Std. Dev.	58.23	60.39	79.39	7,410.64
Observations	12	15	15	219,159
Manufacturing				
Mean	150.58	276.14	192.00	305.17
Std. Dev.	338.35	887.77	592.48	6,807.75
Observations	24	30	27	304,665
Retail Trade				
Mean	1,257.51	1,049.05	853.85	95.35
Std. Dev.	4,287.88	4,162.04	4,491.64	2,277.75
Observations	24	30	27	339,555

Other Firms				
Mean	201.80	80.97	136.80	122.79
Std. Dev.	1,523.91	680.73	1,110.09	9,471.92
Observations	174	222	180	2,955,702

Note: Figures are expressed in New Zealand Dollars (in Thousands). S = Suppressed mean values where underlying observations are <20 as per the rule Statistics New Zealand’s microdata output guide 4.3.3.

Appendix Table 4.21: Summary Statistics of Flood-Affected Firms' Business Equity

		Flooded Firms			Control Firms
		Before Floods (1)	During Floods (2)	After Floods (3)	During Floods (4)
Agriculture					
	Mean	0.48	0.36	0.26	-8.59
	Std. Dev.	1.23	2.18	2.86	2,389.52
	Observations	210	240	216	1,418,250
Wholesale Trade					
	Mean	S	S	S	-15.49
	Std. Dev.	1.63	0.81	0.95	2,522.95
	Observations	6	12	9	187,920
Financial and Insurance					
	Mean	S	S	S	-83.45
	Std. Dev.	1.45	0.55	0.98	20,414.88
	Observations	12	15	12	206,181
Construction					
	Mean	0.26	0.06	-0.72	-8.04
	Std. Dev.	0.5	1.41	3.08	1,552.45
	Observations	24	27	21	683,034
Transport					
	Mean	S	S	S	-4.62
	Std. Dev.	0.59	0.56	0.44	425.2
	Observations	12	15	12	201,948
Manufacturing					
	Mean	-15.51	-57.71	-59.18	-9.45
	Std. Dev.	77.6	304.47	304.95	1,929.76
	Observations	24	27	27	286,353
Retail Trade					
	Mean	0.10	0.23	0.22	-18.68
	Std. Dev.	1.23	0.70	1.19	2,046.21
	Observations	27	30	27	320,973

Other Firms				
Mean	0.31	0.31	0.34	-13.37
Std. Dev.	1.43	1.27	1.51	2,885.22
Observations	159	207	168	2,738,487

Note: Figures are expressed in New Zealand Dollars (in Thousands). S = Suppressed mean values where underlying observations are <20 as per the rule Statistics New Zealand's microdata output guide 4.3.3.

Appendix Table 4.22: Impact of Floods on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	29.82	-2.336
	(17.09)	(3.636)
$Flood_{it-1}$	-15.68	-5.752
	(34.18)	(6.121)
$Flood_{it}$	-2.617	-5.038
	(8.868)	(3.878)
$Flood_{it+1}$	-5.627	-1.963
	(11.37)	(5.364)
$Flood_{it+2}$	16.56	-2.334
	(14.80)	(4.696)
R^2 (within)	0.0002	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	179,628	177,771
Total of observations	1,456,878	1,418,487

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.23: Impact of Floods on Financial Indicators of Wholesale Trading Firms (F)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	445.5	-3.183
	(352.8)	(9.582)
$Flood_{it-1}$	230.9	-1.202
	(213.2)	(10.05)
$Flood_{it}$	461.9	68.39
	(333.0)	(48.34)
$Flood_{it+1}$	-207.3	28.60
	(133.4)	(26.24)
$Flood_{it+2}$	-367.1	43.75
	(242.5)	(37.44)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.0000	0.0000
Number of firms	41,337	39,828
Total of observations	201,492	187,935

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.24: Impact of Floods on Financial Indicators of Financial and Insurance Services Firms (K)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-575.0	-68.68
	(444.5)	(195.5)
$Flood_{it-1}$	-552.0	209.0
	(383.9)	(390.7)
$Flood_{it}$	-852.7**	-53.22
	(373.4)	(190.1)
$Flood_{it+1}$	-1,540***	-111.4
	(556.5)	(215.4)
$Flood_{it+2}$	-1,037**	-147.0
	(453.1)	(274.6)
R^2 (within)	0.001	0.0001
R^2 (between)	0.000	0.0000
Number of firms	57,090	53,604
Total of observations	231,540	206,196

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.25: Impact of Floods on Financial Indicators of Construction Firms (E)

	Profit (1)	Business Equity (2)
$Flood_{it-2}$	-87.67	1.829
	(84.15)	(4.076)
$Flood_{it-1}$	-127.4	4.943
	(79.87)	(3.669)
$Flood_{it}$	-130.7	13.64
	(94.36)	(8.784)
$Flood_{it+1}$	-61.64	11.88
	(69.19)	(9.203)
$Flood_{it+2}$	-51.34	11.62
	(71.25)	(7.065)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	156,087	152,514
Total of observations	720,129	683,061

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.26: Impact of Floods on Financial Indicators of Transport, Postal, and Warehousing Firms (I)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	25.24	-4.982***
	(63.73)	(1.629)
$Flood_{it-1}$	232.8	-3.272
	(178.6)	(4.313)
$Flood_{it}$	184.1	-1.521
	(127.4)	(4.189)
$Flood_{it+1}$	87.98	-4.897
	(71.16)	(3.182)
$Flood_{it+2}$	112.0	-2.275
	(78.05)	(2.686)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.0000	0.0003
Number of firms	46,083	44,607
Total of observations	219,171	201,960

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.27: Impact of Floods on Financial Indicators of Manufacturing Firms (C)

	Profit (1)	Business Equity (2)
$Flood_{it-2}$	149.4***	1.761
	(54.51)	(22.11)
$Flood_{it-1}$	16.55	12.24
	(104.5)	(28.32)
$Flood_{it}$	164.8	-52.10
	(101.5)	(53.00)
$Flood_{it+1}$	37.64	-47.52
	(91.83)	(56.72)
$Flood_{it+2}$	9.538	-7.808
	(37.88)	(11.93)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	54,159	52,623
Total of observations	304,692	286,380

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.28: Impact of Floods on Financial Indicators of Retail Trade Firms (G)

	Profit (1)	Business Equity (2)
$Flood_{it-2}$	-1,287	5.306
	(956.1)	(8.146)
$Flood_{it-1}$	-200.0	14.28
	(373.0)	(13.45)
$Flood_{it}$	-156.6	17.96
	(261.3)	(13.30)
$Flood_{it+1}$	-177.3	23.82
	(176.8)	(15.77)
$Flood_{it+2}$	-101.1	16.79
	(120.9)	(14.37)
R^2 (within)	0.0005	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	75,411	73,302
Total of observations	339,582	321,000

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.29: Impact of Floods on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S)

	Profit	Business Equity
	(1)	**(2)**
$Flood_{it-2}$	-65.38	7.841
	(68.81)	(5.451)
$Flood_{it-1}$	-13.94	4.626
	(68.53)	(2.883)
$Flood_{it}$	-78.08	5.088
	(42.97)	(2.687)
$Flood_{it+1}$	-20.71	3.870**
	(55.75)	(1.871)
$Flood_{it+2}$	37.72	2.933
	(79.87)	(2.312)
R^2 (within)	0.0000	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	581,496	560,247
Total of observations	2,955,927	2,738,691

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.30: Impact of Floods on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	0.00282	-0.000520
	(0.00162)	(0.000809)
$Flood_{it-1}$	-0.00148	-0.00128
	(0.00323)	(0.00136)
$Flood_{it}$	-0.000247	-0.00112
	(0.000838)	(0.000863)
$Flood_{it+1}$	-0.000532	-0.000437
	(0.00108)	(0.00119)
$Flood_{it+2}$	0.00157	-0.000519
	(0.00140)	(0.00104)
R^2 (within)	0.0002	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	179,628	177,771
Total of observations	1,456,878	1,418,487

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.31: Impact of Floods on Financial Indicators of Wholesale Trading Firms (F) (Standardized Coefficients)

	Profit (1)	Business Equity (2)
$Flood_{it-2}$	0.0421	-0.000708
	(0.0334)	(0.00213)
$Flood_{it-1}$	0.0218	-0.000267
	(0.0202)	(0.00224)
$Flood_{it}$	0.0437	0.0152
	(0.0315)	(0.0108)
$Flood_{it+1}$	-0.0196	0.00636
	(0.0126)	(0.00584)
$Flood_{it+2}$	-0.0347	0.00973
	(0.0229)	(0.00833)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.0000	0.0000
Number of firms	41,337	39,828
Total of observations	201,492	187,935

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.32: Impact of Floods on Financial Indicators of Financial and Insurance Services Firms (K) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-0.0544	-0.0153
	(0.0420)	(0.0435)
$Flood_{it-1}$	-0.0522	0.0465
	(0.0363)	(0.0869)
$Flood_{it}$	-0.0806**	-0.0118
	(0.0353)	(0.0423)
$Flood_{it+1}$	-0.146***	-0.0248
	(0.0526)	(0.0479)
$Flood_{it+2}$	-0.0981**	-0.0327
	(0.0428)	(0.0611)
R^2 (within)	0.001	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	57,090	53,604
Total of observations	231,540	206,196

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.33: Impact of Floods on Financial Indicators of Construction Firms (E) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-0.00829	0.000407
	(0.00796)	(0.000907)
$Flood_{it-1}$	-0.0120	0.00110
	(0.00755)	(0.000816)
$Flood_{it}$	-0.0124	0.00303
	(0.00892)	(0.00195)
$Flood_{it+1}$	-0.00583	0.00264
	(0.00654)	(0.00205)
$Flood_{it+2}$	-0.00485	0.00259
	(0.00674)	(0.00157)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	156,087	152,514
Total of observations	720,129	683,061

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.34: Impact of Floods on Financial Indicators of Transport, Postal, and Warehousing Firms (I) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	0.00239	-0.00111***
	(0.00603)	(0.000362)
$Flood_{it-1}$	0.0220	-0.000728
	(0.0169)	(0.000959)
$Flood_{it}$	0.0174	-0.000338
	(0.0121)	(0.000932)
$Flood_{it+1}$	0.00832	-0.00109
	(0.00673)	(0.000708)
$Flood_{it+2}$	0.0106	-0.000506
	(0.00738)	(0.000598)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.0000	0.0003
Number of firms	46,083	44,607
Total of observations	219,171	201,960

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.35: Impact of Floods on Financial Indicators of Manufacturing Firms (C) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	0.0141***	0.000392
	(0.00515)	(0.00492)
$Flood_{it-1}$	0.00157	0.00272
	(0.00988)	(0.00630)
$Flood_{it}$	0.0156	-0.0116
	(0.00960)	(0.0118)
$Flood_{it+1}$	0.00356	-0.0106
	(0.00868)	(0.0126)
$Flood_{it+2}$	0.000902	-0.00174
	(0.00358)	(0.00265)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0002	0.0000
Number of firms	54,159	52,623
Total of observations	304,692	286,380

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.36: Impact of Floods on Financial Indicators of Retail Trade Firms (G) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-0.122	0.00118
	(0.0904)	(0.00181)
$Flood_{it-1}$	-0.0189	0.00318
	(0.0353)	(0.00299)
$Flood_{it}$	-0.0148	0.00400
	(0.0247)	(0.00296)
$Flood_{it+1}$	-0.0168	0.00530
	(0.0167)	(0.00351)
$Flood_{it+2}$	-0.00956	0.00373
	(0.0114)	(0.00320)
R^2 (within)	0.0005	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	75,411	73,302
Total of observations	339,582	321,000

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.37: Impact of Floods on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-0.00618	0.00174
	(0.00651)	(0.00121)
$Flood_{it-1}$	-0.00132	0.00103
	(0.00648)	(0.000641)
$Flood_{it}$	-0.00738	0.00113
	(0.00406)	(0.000598)
$Flood_{it+1}$	-0.00196	0.000861**
	(0.00527)	(0.000416)
$Flood_{it+2}$	0.00357	0.000653
	(0.00755)	(0.000514)
R^2 (within)	0.0000	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	581,496	560,247
Total of observations	2,955,927	2,738,691

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.38: Summary Statistics of Wildfire-Affected Forestry Firms

	Wildfire-Affected Firms			Control Firms
	Before Fire	**During Fire**	**After Fire**	**During Fire**
	(1)	**(2)**	**(3)**	**(4)**
Profit				
Mean	S	S	S	203.96
Std. Dev.	30.94	497.53	20.23	9,217.10
Observations	15	18	15	71,655
Business Equity				
Mean	S	S	S	-2.48
Std. Dev.	2.53	0.35	0.37	178.76
Observations	15	15	15	65,721

Note: Figures are expressed in New Zealand Dollars (in Thousands). S = Suppressed mean values where underlying observations are <20 as per the rule Statistics New Zealand's microdata output guide 4.3.3.

Appendix Table 4.39: Impact of Wildfires on Forestry Firms' Profit and Business Equity (Absolute Coefficient)

	Profit	**Business Equity**
	(1)	**(2)**
$Fire_{it-2}$	-28.96	-1.069
	(83.40)	(0.708)
$Fire_{it-1}$	-44.58	-1.723
	(66.91)	(1.451)
$Fire_{it}$	302.4	-0.449
	(169.1)	(1.125)
$Fire_{it+1}$	159.0	-0.902
	(149.3)	(0.643)
$Fire_{it+2}$	100.1	0.219
	(135.0)	(0.721)
R^2 (within)	0.0011	0.0004
R^2 (between)	0.0003	0.0000
Number of firms	10,599	10,245
Total of observations	71,670	65,736

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.40: Impact of Wildfires on Forestry Firms' Profit and Business Equity (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Fire_{it-2}$	-0.00274	-0.000238
	(0.00789)	(0.000158)
$Fire_{it-1}$	-0.00422	-0.000383
	(0.00633)	(0.000323)
$Fire_{it}$	0.0286	-9.98e-05
	(0.0160)	(0.000250)
$Fire_{it+1}$	0.0150	-0.000201
	(0.0141)	(0.000143)
$Fire_{it+2}$	0.00946	4.88e-05
	(0.0128)	(0.000160)
R^2 (within)	0.0011	0.0004
R^2 (between)	0.0003	0.0000
Number of firms	10,599	10,245
Total of observations	71,670	65,736

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.41: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildifires	-20.76**	-2.066**
	(8.471)	(1.005)
R^2 (within)	0.0002	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	179,628	177,771
Total of observations	1,456,884	1,418,490

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.42: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Wholesale Trading Firms (F)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildifires	44.32	13.43
	(70.75)	(8.765)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.0000	0.0000
Number of firms	41,337	39,828
Total of observations	201,495	187,932

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.43: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Financial and Insurance Services Firms (K)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-1,210***	-9.430
	(401.9)	(11.83)
R^2 (within)	0.001	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	57,090	53,604
Total of observations	231,546	206,199

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.44: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Construction Firms (E)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-34.81	-0.150
	(21.26)	(1.309)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	156,087	152,514
Total of observations	720,129	683,061

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.45: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Transport, Postal, and Warehousing Firms (I)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildifires	-70.21	0.457
	(36.72)	(1.301)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.0000	0.0000
Number of firms	46,083	44,607
Total of observations	219,177	201,966

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.46: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Manufacturing Firms (C)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildifires	-58.24	-12.97
	(62.39)	(11.83)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	54,159	52,623
Total of observations	304,695	286,380

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.47: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Retail Trade Firms (G)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-17.94	8.755
	(34.96)	(9.220)
R^2 (within)	0.0004	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	75,414	73,302
Total of observations	339,588	321,006

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.48: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-14.45	-1.609
	(14.77)	(0.828)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	581,499	560,250
Total of observations	2,955,939	2,738,697

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.49: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Agriculture, Forestry, and Fishing Firms (A) (Standardized Coefficients)

	Profit (1)	Business Equity (2)
Cyclones_Floods_Wildifires	-0.00196**	-0.000460**
	(0.000801)	(0.000224)
R^2 (within)	0.0002	0.000
R^2 (between)	0.000	0.000
Number of firms	179,628	177,771
Total of observations	1,456,884	1,418,490

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.50: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Wholesale Trading Firms (F) (Standardized Coefficients)

	Profit (1)	Business Equity (2)
Cyclones_Floods_Wildifires	0.00419	0.00299
	(0.00669)	(0.00195)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.000	0.000
Number of firms	41,337	39,828
Total of observations	201,495	187,932

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.51: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Financial and Insurance Services Firms (K) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
Cyclones_Floods_Wildifires	-0.114***	-0.00210
	(0.0380)	(0.00263)
R^2 (within)	0.001	0.0001
R^2 (between)	0.000	0.000
Number of firms	57,090	53,604
Total of observations	231,546	206,199

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.52: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Construction Firms (E) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
Cyclones_Floods_Wildifires	-0.00329	-3.33e-05
	(0.00201)	(0.000291)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	156,087	152,514
Total of observations	720,129	683,061

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.53: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Transport, Postal, and Warehousing Firms (I) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-0.00664	0.000102
	(0.00347)	(0.000290)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.000	0.000
Number of firms	46,083	44,607
Total of observations	219,177	201,966

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.54: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Manufacturing Firms (C) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-0.00551	-0.00288
	(0.00590)	(0.00263)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	54,159	52,623
Total of observations	304,695	286,380

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.55: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Retail Trade Firms (G) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-0.00170	0.00195
	(0.00331)	(0.00205)
R^2 (within)	0.0004	0.0001
R^2 (between)	0.000	0.000
Number of firms	75,414	73,302
Total of observations	339,588	321,006

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.56: Impact of Extratropical Cyclones, Floods, and Wildfires on Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
Cyclones_Floods_Wildfires	-0.00137	-0.000352
	(0.00126)	(0.000264)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	581,499	560,250
Total of observations	2,955,939	2,738,697

Regression coefficients are as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.57: Extratropical Cyclones and Financial Indicators of Agriculture, Forestry, and Fishing Firms (A)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	4.965	9.232
	(21.86)	(5.427)
$Cyclone_{it-1}$	-12.76	15.81
	(14.46)	(10.20)
$Cyclone_{it}$	-43.93**	2.697
	(17.41)	(2.546)
$Cyclone_{it+1}$	-18.38	0.904
	(15.02)	(3.395)
$Cyclone_{it+2}$	-38.28	2.754
	(26.67)	(2.522)
R^2 (within)	0.0002	0.000
R^2 (between)	0.0000	0.0000
Number of firms	116,949	114,936
Total of observations	694,158	671,592

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.58: Extratropical Cyclones and Financial Indicators of Wholesale Trading Firms (F)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-35.60	8.663
	(54.34)	(4.994)
$Cyclone_{it-1}$	-120.9	129.3
	(107.3)	(82.06)
$Cyclone_{it}$	-220.0***	39.48
	(85.01)	(25.03)
$Cyclone_{it+1}$	-278.8	37.61
	(167.4)	(24.51)
$Cyclone_{it+2}$	-852.3	38.09
	(598.8)	(24.28)
R^2 (within)	0.0001	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	32,277	31,596
Total of observations	138,387	133,344

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.59: Extratropical Cyclones and Financial Indicators of Financial and Insurance Services Firms (K)

	Profit	Business Equity
	(1)	**(2)**
$Cyclone_{it-2}$	-205.9	379.5
	(281.8)	(358.3)
$Cyclone_{it-1}$	-412.7	102.8
	(287.8)	(96.88)
$Cyclone_{it}$	-1,316**	94.02
	(511.4)	(93.48)
$Cyclone_{it+1}$	-970.4***	93.71
	(365.2)	(90.55)
$Cyclone_{it+2}$	-334.4	91.94
	(350.9)	(90.11)
R^2 (within)	0.0004	0.000
R^2 (between)	0.0000	0.0000
Number of firms	38,313	36,945
Total of observations	129,762	122,169

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.60: Extratropical Cyclones and Financial Indicators of Construction Firms (E)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-1.213	19.01
	(12.87)	(16.67)
$Cyclone_{it-1}$	5.318	18.19**
	(15.64)	(8.547)
$Cyclone_{it}$	-21.88	6.556
	(25.24)	(4.771)
$Cyclone_{it+1}$	9.000	6.610
	(17.58)	(4.751)
$Cyclone_{it+2}$	9.705	2.472
	(15.34)	(6.470)
R^2 (within)	0.0001	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	114,507	111,264
Total of observations	448,806	422,775

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.61: Extratropical Cyclones and Financial Indicators of Transport, Postal, and Warehousing Firms (I)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-112.3	1.768
	(73.72)	(1.790)
$Cyclone_{it-1}$	-102.8	2.924
	(77.21)	(2.124)
$Cyclone_{it}$	-160.0**	1.753
	(77.18)	(2.232)
$Cyclone_{it+1}$	-138.6**	0.715
	(68.20)	(1.696)
$Cyclone_{it+2}$	-70.66	1.333
	(109.1)	(1.928)
R^2 (within)	0.0002	0.0004
R^2 (between)	0.0000	0.0000
Number of firms	31,692	30,324
Total of observations	126,624	115,503

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.62: Extratropical Cyclones and Financial Indicators of Manufacturing Firms (C)

	Profit (1)	Business Equity (2)
$Cyclone_{it-2}$	-82.98**	4.553
	(40.38)	(4.494)
$Cyclone_{it-1}$	-72.41**	5.757
	(36.80)	(7.824)
$Cyclone_{it}$	-176.0**	-0.808
	(76.20)	(3.157)
$Cyclone_{it+1}$	-150.5***	-1.049
	(37.37)	(3.210)
$Cyclone_{it+2}$	22.50	-1.328
	(61.52)	(3.170)
R^2 (within)	0.0003	0.0001
R^2 (between)	0.0000	0.0000
Number of firms	40,332	39,504
Total of observations	195,879	188,748

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.63: Extratropical Cyclones and Financial Indicators of Retail Trade Firms (G)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	9.428	23.78
	(27.91)	(41.85)
$Cyclone_{it-1}$	-26.28	12.74
	(19.39)	(10.99)
$Cyclone_{it}$	-19.61	7.370
	(15.23)	(8.275)
$Cyclone_{it+1}$	-26.55	-26.40
	(16.54)	(26.82)
$Cyclone_{it+2}$	-21.35	-9.816
	(17.20)	(11.52)
R^2 (within)	0.001	0.0002
R^2 (between)	0.0000	0.0000
Number of firms	55,326	53,802
Total of observations	218,433	208,029

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.64: Extratropical Cyclones and Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-9.218	-0.346
	(16.20)	(11.77)
$Cyclone_{it-1}$	-47.76	5.985
	(24.61)	(5.823)
$Cyclone_{it}$	-16.01	-1.787
	(17.89)	(4.109)
$Cyclone_{it+1}$	-11.93	-0.331
	(23.47)	(4.191)
$Cyclone_{it+2}$	-52.75***	-1.944
	(17.19)	(4.139)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	430,233	412,809
Total of observations	1,834,938	1,710,699

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.65: Extratropical Cyclones and Financial Indicators of Agriculture, Forestry, and Fishing Firms (A) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	0.000430	0.00274
	(0.00190)	(0.00161)
$Cyclone_{it-1}$	-0.00111	0.00469
	(0.00125)	(0.00303)
$Cyclone_{it}$	-0.00381**	0.000800
	(0.00151)	(0.000755)
$Cyclone_{it+1}$	-0.00159	0.000268
	(0.00130)	(0.00101)
$Cyclone_{it+2}$	-0.00332	0.000817
	(0.00231)	(0.000748)
R^2 (within)	0.0002	0.000
R^2 (between)	0.000	0.000
Number of firms	694,158	671,592
Total of observations	116,949	114,936

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.66: Extratropical Cyclones and Financial Indicators of Wholesale Trading Firms (F) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.00309	0.00257
	(0.00471)	(0.00148)
$Cyclone_{it-1}$	-0.0105	0.0384
	(0.00930)	(0.0243)
$Cyclone_{it}$	-0.0191***	0.0117
	(0.00737)	(0.00743)
$Cyclone_{it+1}$	-0.0242	0.0112
	(0.0145)	(0.00727)
$Cyclone_{it+2}$	-0.0739	0.0113
	(0.0519)	(0.00720)
R^2 (within)	0.0001	0.0002
R^2 (between)	0.000	0.000
Number of firms	32,277	31,596
Total of observations	138,387	133,344

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.67: Extratropical Cyclones and Financial Indicators of Financial and Insurance Services Firms (K) (Standardized Coefficients)

	Profit	Business Equity
	(1)	**(3)**
$Cyclone_{it-2}$	-0.0178	0.113
	(0.0244)	(0.106)
$Cyclone_{it-1}$	-0.0358	0.0305
	(0.0249)	(0.0287)
$Cyclone_{it}$	-0.114**	0.0279
	(0.0443)	(0.0277)
$Cyclone_{it+1}$	-0.0841***	0.0278
	(0.0317)	(0.0269)
$Cyclone_{it+2}$	-0.0290	0.0273
	(0.0304)	(0.0267)
R^2 (within)	0.0004	0.0001
R^2 (between)	0.000	0.000
Number of firms	38,313	36,945
Total of observations	129,762	122,169

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.68: Extratropical Cyclones and Financial Indicators of Construction Firms (E) (Standardized Coefficients)

	Profit	Business Equity
	(1)	**(2)**
$Cyclone_{it-2}$	-0.000105	0.00564
	(0.00112)	(0.00495)
$Cyclone_{it-1}$	0.000461	0.00540**
	(0.00136)	(0.00254)
$Cyclone_{it}$	-0.00190	0.00195
	(0.00219)	(0.00142)
$Cyclone_{it+1}$	0.000780	0.00196
	(0.00152)	(0.00141)
$Cyclone_{it+2}$	0.000841	0.000734
	(0.00133)	(0.00192)
R^2 (within)	0.0001	0.0001
R^2 (between)	0.000	0.000
Number of firms	114,507	111,264
Total of observations	448,806	422,775

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.69: Extratropical Cyclones and Financial Indicators of Transport, Postal, and Warehousing Firms (I) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(2)**
$Cyclone_{it-2}$	-0.00973	0.000525
	(0.00639)	(0.000531)
$Cyclone_{it-1}$	-0.00891	0.000868
	(0.00669)	(0.000630)
$Cyclone_{it}$	-0.0139**	0.000520
	(0.00669)	(0.000662)
$Cyclone_{it+1}$	-0.0120**	0.000212
	(0.00591)	(0.000503)
$Cyclone_{it+2}$	-0.00612	0.000395
	(0.00946)	(0.000572)
R^2 (within)	0.0002	0.0004
R^2 (between)	0.000	0.000
Number of firms	31,692	30,324
Total of observations	126,624	115,503

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.70: Extratropical Cyclones and Financial Indicators of Manufacturing Firms (C) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.00719**	0.00135
	(0.00350)	(0.00133)
$Cyclone_{it-1}$	-0.00628**	0.00171
	(0.00319)	(0.00232)
$Cyclone_{it}$	-0.0153**	-0.000240
	(0.00661)	(0.000937)
$Cyclone_{it+1}$	-0.0130***	-0.000311
	(0.00324)	(0.000953)
$Cyclone_{it+2}$	0.00195	-0.000394
	(0.00533)	(0.000941)
R^2 (within)	0.0003	0.0001
R^2 (between)	0.000	0.000
Number of firms	40,332	39,504
Total of observations	195,879	188,748

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.71: Extratropical Cyclones and Financial Indicators of Retail Trade Firms (G) (Standardized Coefficients)

	Profit (1)	Business Equity (2)
$Cyclone_{it-2}$	0.000817	0.00705
	(0.00242)	(0.0124)
$Cyclone_{it-1}$	-0.00228	0.00378
	(0.00168)	(0.00326)
$Cyclone_{it}$	-0.00170	0.00219
	(0.00132)	(0.00246)
$Cyclone_{it+1}$	-0.00230	-0.00783
	(0.00143)	(0.00796)
$Cyclone_{it+2}$	-0.00185	-0.00291
	(0.00149)	(0.00342)
R^2 (within)	0.001	0.0002
R^2 (between)	0.000	0.000
Number of firms	55,326	53,802
Total of observations	218,433	208,029

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.72: Extratropical Cyclones and Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.000799	-0.000103
	(0.00140)	(0.00349)
$Cyclone_{it-1}$	-0.00414	0.00178
	(0.00213)	(0.00173)
$Cyclone_{it}$	-0.00139	-0.000530
	(0.00155)	(0.00122)
$Cyclone_{it+1}$	-0.00103	-9.81e-05
	(0.00203)	(0.00124)
$Cyclone_{it+2}$	-0.00457***	-0.000577
	(0.00149)	(0.00123)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	430,233	412,809
Total of observations	1,834,938	1,710,699

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.73: Floods and Financial Indicators of Agriculture, Forestry, and Fishing Firms (A)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	29.57	-2.348
	(18.41)	(3.925)
$Flood_{it-1}$	-16.06	-5.828
	(31.07)	(6.538)
$Flood_{it}$	-2.916	-5.123
	(8.081)	(4.727)
$Flood_{it+1}$	-5.878	-1.987
	(11.79)	(5.713)
$Flood_{it+2}$	17.81	-2.394
	(11.10)	(5.122)
R^2 (within)	0.0003	0.000
R^2 (between)	0.000	0.000
Number of firms	178,638	176,781
Total of observations	1,433,217	1,395,147

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.74: Floods and Financial Indicators of Wholesale Trading Firms (F)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	443.0	-2.855
	(322.3)	(7.999)
$Flood_{it-1}$	228.6	-1.372
	(163.0)	(8.534)
$Flood_{it}$	459.9	68.70
	(290.8)	(51.07)
$Flood_{it+1}$	-209.8	28.71
	(162.6)	(25.74)
$Flood_{it+2}$	-369.9	44.05
	(274.1)	(36.26)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.000	0.000
Number of firms	41,220	39,720
Total of observations	200,547	187,089

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.75: Floods and Financial Indicators of Financial and Insurance Services Firms (K)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-561.5	-69.00
	(407.6)	(182.4)
$Flood_{it-1}$	-545.1	209.3
	(378.5)	(387.1)
$Flood_{it}$	-848.2**	-53.51
	(378.7)	(187.5)
$Flood_{it+1}$	-1,499**	-111.9
	(591.6)	(211.8)
$Flood_{it+2}$	-1,023**	-147.6
	(401.1)	(273.6)
R^2 (within)	0.0006	0.0002
R^2 (between)	0.000	0.000
Number of firms	56,955	53,478
Total of observations	230,871	205,572

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.76: Floods and Financial Indicators of Construction Firms (E)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-87.68	1.663
	(62.00)	(5.649)
$Flood_{it-1}$	-127.4	4.914
	(83.40)	(4.355)
$Flood_{it}$	-130.7	13.68
	(85.79)	(7.522)
$Flood_{it+1}$	-61.67	11.89
	(54.20)	(7.554)
$Flood_{it+2}$	-51.40	11.67
	(75.31)	(6.481)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	155,817	152,250
Total of observations	717,495	680,577

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.77: Floods and Financial Indicators of Transport, Postal, and Warehousing Firms (I)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	25.33	-5.001***
	(86.28)	(1.802)
$Flood_{it-1}$	233.2	-3.284
	(174.5)	(4.476)
$Flood_{it}$	184.4	-1.534
	(128.2)	(4.668)
$Flood_{it+1}$	88.14	-4.915
	(79.33)	(3.408)
$Flood_{it+2}$	112.3	-2.284
	(81.58)	(2.766)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.000	0.000
Number of firms	46,011	44,538
Total of observations	218,544	201,384

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.78: Floods and Financial Indicators of Manufacturing Firms (C)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	150.0	1.579
	(108.3)	(21.51)
$Flood_{it-1}$	16.19	12.15
	(107.1)	(29.01)
$Flood_{it}$	165.4	-52.49
	(126.7)	(49.50)
$Flood_{it+1}$	38.73	-47.60
	(105.3)	(55.82)
$Flood_{it+2}$	8.933	-7.955
	(42.82)	(11.91)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	53,976	52,440
Total of observations	302,727	284,556

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.79: Floods and Financial Indicators of Retail Trade Firms (G)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-1,286	5.134
	(1,002)	(8.092)
$Flood_{it-1}$	-199.8	14.28
	(327.1)	(13.76)
$Flood_{it}$	-156.2	17.96
	(155.9)	(13.99)
$Flood_{it+1}$	-177.3	23.79
	(157.7)	(17.20)
$Flood_{it+2}$	-101.3	17.21
	(140.7)	(14.44)
R^2 (within)	0.0005	0.0001
R^2 (between)	0.000	0.000
Number of firms	74,922	72,831
Total of observations	336,237	317,871

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.80: Floods and Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-65.31	8.002
	(50.28)	(6.234)
$Flood_{it-1}$	-13.75	4.609
	(90.80)	(3.123)
$Flood_{it}$	-78.03**	5.081
	(38.71)	(4.273)
$Flood_{it+1}$	-20.76	3.867
	(35.78)	(2.060)
$Flood_{it+2}$	38.21	2.976
	(61.35)	(2.814)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	579,636	558,480
Total of observations	2,942,139	2,725,869

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.81: Floods and Financial Indicators of Agriculture, Forestry, and Fishing Firms (A) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	0.00280	-0.000522
	(0.00174)	(0.000873)
$Flood_{it-1}$	-0.00152	-0.00130
	(0.00294)	(0.00145)
$Flood_{it}$	-0.000276	-0.00114
	(0.000764)	(0.00105)
$Flood_{it+1}$	-0.000556	-0.000442
	(0.00112)	(0.00127)
$Flood_{it+2}$	0.00168	-0.000533
	(0.00105)	(0.00114)
R^2 (within)	0.0003	0.000
R^2 (between)	0.000	0.000
Number of firms	178,638	176,781
Total of observations	1,433,217	1,395,147

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.82: Floods and Financial Indicators of Wholesale Trading Firms (F) (Standardized Coefficients)

	Profit (1)	Business Equity (3)
$Flood_{it-2}$	0.0419	-0.000635
	(0.0305)	(0.00178)
$Flood_{it-1}$	0.0216	-0.000305
	(0.0154)	(0.00190)
$Flood_{it}$	0.0435	0.0153
	(0.0275)	(0.0114)
$Flood_{it+1}$	-0.0198	0.00639
	(0.0154)	(0.00573)
$Flood_{it+2}$	-0.0350	0.00980
	(0.0259)	(0.00807)
R^2 (within)	0.0002	0.0002
R^2 (between)	0.000	0.000
Number of firms	41,220	39,720
Total of observations	200,547	187,089

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.83: Floods and Financial Indicators of Financial and Insurance Services Firms (K) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-0.0531	-0.0153
	(0.0385)	(0.0406)
$Flood_{it-1}$	-0.0515	0.0466
	(0.0358)	(0.0861)
$Flood_{it}$	-0.0802**	-0.0119
	(0.0358)	(0.0417)
$Flood_{it+1}$	-0.142**	-0.0249
	(0.0559)	(0.0471)
$Flood_{it+2}$	-0.0967**	-0.0328
	(0.0379)	(0.0609)
R^2 (within)	0.001	0.0002
R^2 (between)	0.000	0.000
Number of firms	56,955	53,478
Total of observations	230,871	205,572

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.84: Floods and Financial Indicators of Construction Firms (E) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-0.00829	0.000370
	(0.00586)	(0.00126)
$Flood_{it-1}$	-0.0120	0.00109
	(0.00789)	(0.000969)
$Flood_{it}$	-0.0124	0.00304
	(0.00811)	(0.00167)
$Flood_{it+1}$	-0.00583	0.00265
	(0.00513)	(0.00168)
$Flood_{it+2}$	-0.00486	0.00260
	(0.00712)	(0.00144)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	155,817	152,250
Total of observations	717,495	680,577

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.85: Floods and Financial Indicators of Transport, Postal, and Warehousing Firms (I) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	0.00240	-0.00111***
	(0.00816)	(0.000401)
$Flood_{it-1}$	0.0221	-0.000731
	(0.0165)	(0.000996)
$Flood_{it}$	0.0174	-0.000341
	(0.0121)	(0.00104)
$Flood_{it+1}$	0.00833	-0.00109
	(0.00750)	(0.000758)
$Flood_{it+2}$	0.0106	-0.000508
	(0.00771)	(0.000615)
R^2 (within)	0.0004	0.0003
R^2 (between)	0.000	0.000
Number of firms	46,011	44,538
Total of observations	218,544	201,384

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.86: Floods and Financial Indicators of Manufacturing Firms (C) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	0.0142	0.000351
	(0.0102)	(0.00478)
$Flood_{it-1}$	0.00153	0.00270
	(0.0101)	(0.00645)
$Flood_{it}$	0.0156	-0.0117
	(0.0120)	(0.0110)
$Flood_{it+1}$	0.00366	-0.0106
	(0.00996)	(0.0124)
$Flood_{it+2}$	0.000845	-0.00177
	(0.00405)	(0.00265)
R^2 (within)	0.0002	0.0001
R^2 (between)	0.000	0.000
Number of firms	53,976	52,440
Total of observations	302,727	284,556

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.87: Floods and Financial Indicators of Retail Trade Firms (G) (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Flood_{it-2}$	-0.122	0.00114
	(0.0947)	(0.00180)
$Flood_{it-1}$	-0.0189	0.00318
	(0.0309)	(0.00306)
$Flood_{it}$	-0.0148	0.00400
	(0.0147)	(0.00311)
$Flood_{it+1}$	-0.0168	0.00529
	(0.0149)	(0.00383)
$Flood_{it+2}$	-0.00958	0.00383
	(0.0133)	(0.00321)
R^2 (within)	0.0005	0.0001
R^2 (between)	0.000	0.000
Number of firms	74,922	72,831
Total of observations	336,237	317,871

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.88: Floods and Financial Indicators of Other Firms (B, D, H, J, L, M, N, O, P, Q, R, and S) (Standardized Coefficients)

	Profit	**Business Equity**
	(1)	**(3)**
$Flood_{it-2}$	-0.00618	0.00178
	(0.00475)	(0.00139)
$Flood_{it-1}$	-0.00130	0.00103
	(0.00859)	(0.000695)
$Flood_{it}$	-0.00738**	0.00113
	(0.00366)	(0.000951)
$Flood_{it+1}$	-0.00196	0.000860
	(0.00338)	(0.000458)
$Flood_{it+2}$	0.00361	0.000662
	(0.00580)	(0.000626)
R^2 (within)	0.000	0.000
R^2 (between)	0.000	0.000
Number of firms	579,636	558,480
Total of observations	2,942,139	2,725,869

Regression coefficients are as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.89: Wildfires and Forestry Firms' Profit and Business Equity (Absolute Coefficient)

	Profit	Business Equity
	(1)	(3)
$Fire_{it-2}$	-26.43	-1.069
	(100.5)	(0.860)
$Fire_{it-1}$	-42.56	-1.715
	(80.47)	(1.393)
$Fire_{it}$	300.8	-0.415
	(175.1)	(1.223)
$Fire_{it+1}$	157.6	-0.937
	(213.4)	(0.607)
$Fire_{it+2}$	96.26	0.232
	(184.1)	(0.810)
R^2 (within)	0.0011	0.0004
R^2 (between)	0.000	0.000
Number of firms	10,557	10,209
Total of observations	71,430	65,529

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.90: Wildfires and Forestry Firms' Profit and Business Equity (Standardized Coefficients)

	Profit	Business Equity
	(1)	(3)
$Fire_{it-2}$	-0.00250	-0.000238
	(0.00950)	(0.000191)
$Fire_{it-1}$	-0.00402	-0.000382
	(0.00761)	(0.000310)
$Fire_{it}$	0.0284	-9.24e-05
	(0.0166)	(0.000272)
$Fire_{it+1}$	0.0149	-0.000209
	(0.0202)	(0.000135)
$Fire_{it+2}$	0.00910	5.16e-05
	(0.0174)	(0.000180)
R^2 (within)	0.0011	0.0004
R^2 (between)	0.000	0.000
Number of firms	10,557	10,209
Total of observations	71,430	65,529

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the meshblock level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.91: Impact of Extratropical Cyclones on Financial Indicators of All Firms

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-19.66	18.56
	(13.20)	(12.66)
$Cyclone_{it-1}$	-54.99***	17.08***
	(16.83)	(5.628)
$Cyclone_{it}$	-83.98***	5.011
	(19.94)	(3.394)
$Cyclone_{it+1}$	-65.79***	3.306
	(20.59)	(3.658)
$Cyclone_{it+2}$	-69.46**	3.472
	(30.51)	(3.355)
R^2 (within)	0.0000	0.0000
R^2 (between)	0.000	0.000
Number of firms	815,505	788,829
Total of observations	3,803,772	3,588,930

Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.92: Impact of Extratropical Cyclones on Financial Indicators of All Firms (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Cyclone_{it-2}$	-0.00170	0.00551
	(0.00114)	(0.00376)
$Cyclone_{it-1}$	-0.00477***	0.00507***
	(0.00146)	(0.00167)
$Cyclone_{it}$	-0.00728***	0.00149
	(0.00173)	(0.00101)
$Cyclone_{it+1}$	-0.00570***	0.000981
	(0.00178)	(0.00109)
$Cyclone_{it+2}$	-0.00602**	0.00103
	(0.00264)	(0.000996)
R^2 (within)	0.0000	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	815,505	788,829
Total of observations	3,803,772	3,588,930

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** p<0.05, *** p<0.01.

Appendix Table 4.93: Impact of Floods on Financial Indicators of All Firms

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-54.09	1.219
	(49.61)	(3.185)
$Flood_{it-1}$	-3.100	5.100
	(34.25)	(3.232)
$Flood_{it}$	-12.33	-1.316
	(22.90)	(3.582)
$Flood_{it+1}$	-22.16	0.246
	(22.59)	(4.681)
$Flood_{it+2}$	-0.946	1.075
	(30.98)	(3.178)
R^2 (within)	0.0000	0.000
R^2 (between)	0.000	0.000
Number of firms	6,429,420	6,043,710
Total of observations	1,136,847	1,102,041

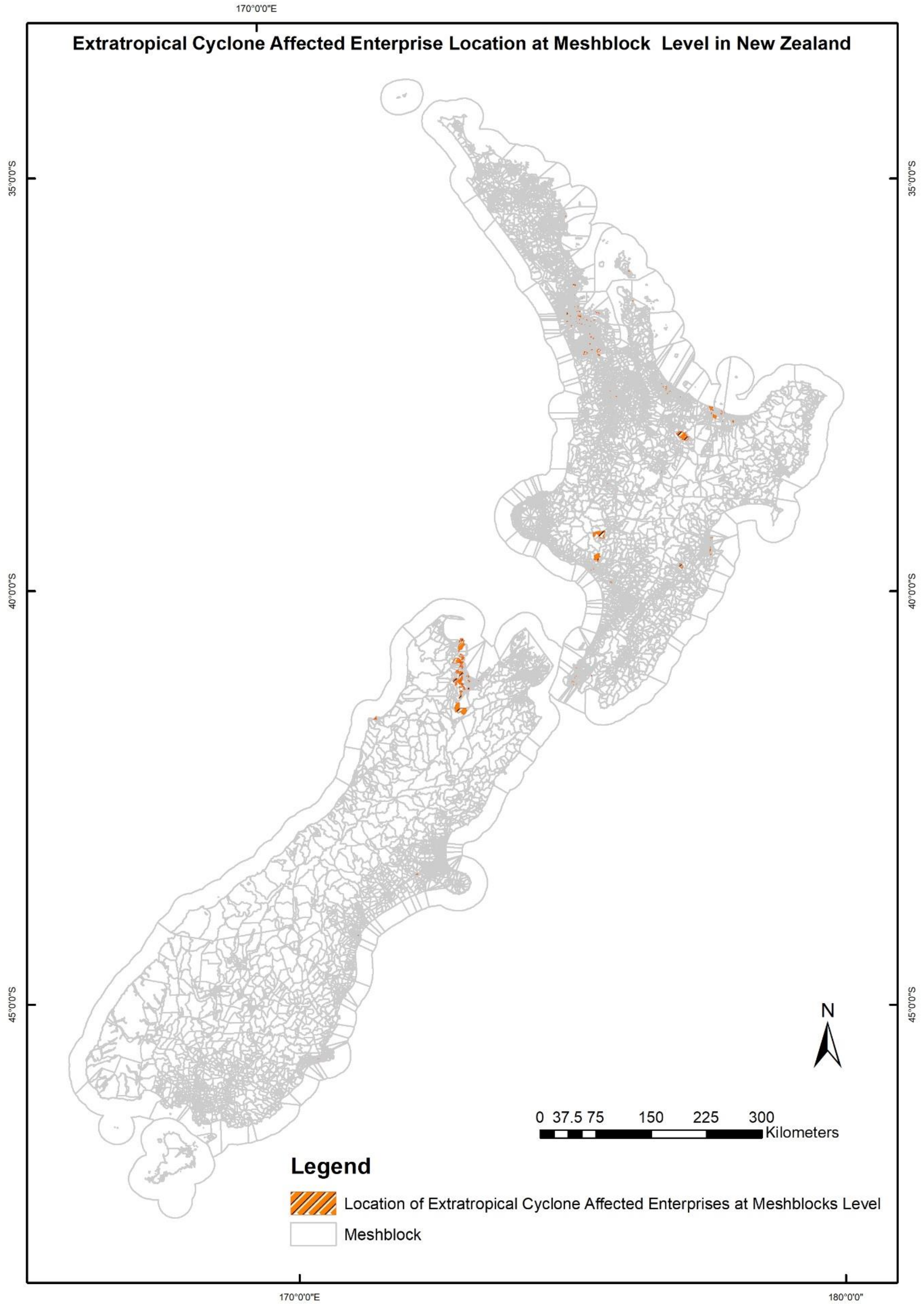
Regression coefficients are expressed in New Zealand Dollars in thousands; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

Appendix Table 4.94: Impact of Floods on Financial Indicators of All Firms (Standardized Coefficients)

	Profit	Business Equity
	(1)	(2)
$Flood_{it-2}$	-0.00511	0.000271
	(0.00469)	(0.000709)
$Flood_{it-1}$	-0.000293	0.00113
	(0.00324)	(0.000719)
$Flood_{it}$	-0.00117	-0.000293
	(0.00217)	(0.000797)
$Flood_{it+1}$	-0.00210	5.48e-05
	(0.00214)	(0.00104)
$Flood_{it+2}$	-8.95e-05	0.000239
	(0.00293)	(0.000707)
R^2 (within)	0.0000	0.0000
R^2 (between)	0.0000	0.0000
Number of firms	1,136,847	1,102,041
Total of observations	6,429,420	6,043,710

Regression coefficients are expressed as standardized coefficients; all regressions include year and firm fixed effects. Clustered standard errors (at the firm level) are in parentheses. ** $p<0.05$, *** $p<0.01$.

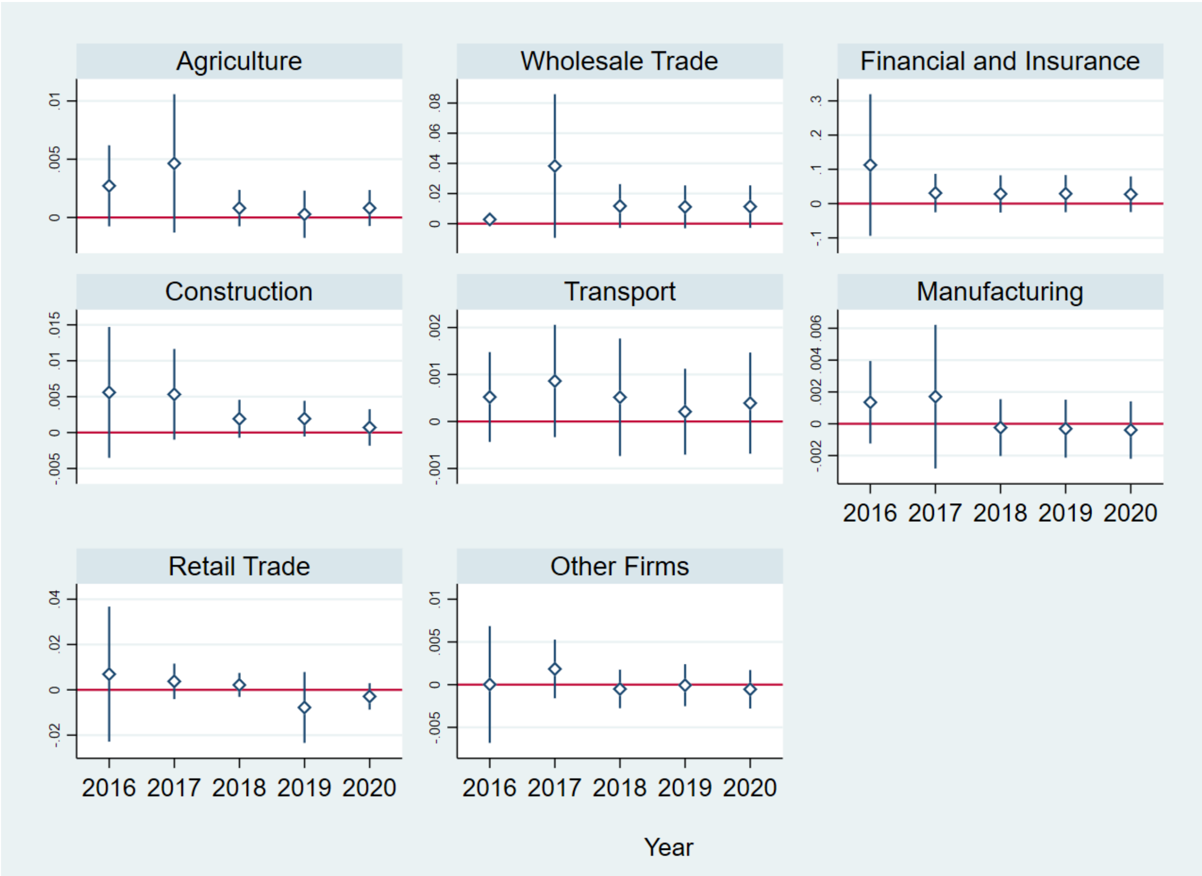
Appendix Figure 4.1: Extratropical Cyclone Affected Firm Location at Meshblocks Level



Appendix Figure 4.2: Impact of Extratropical Cyclones on Firms' Business Equity (Absolute Coefficient)

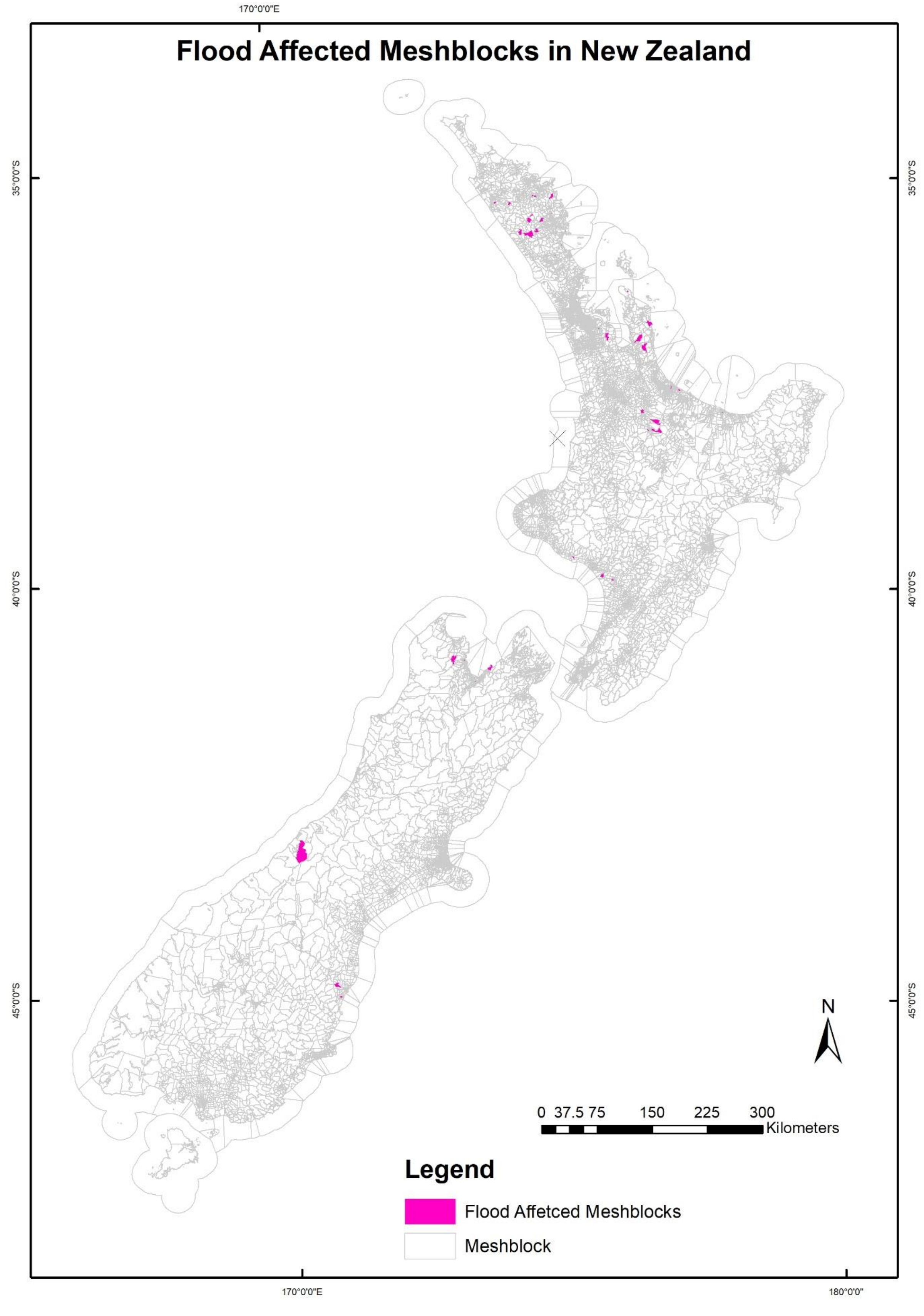
Note: The figures indicate the point estimates of the impact of extratropical cyclones (occurred during FY2018) on firms' business equity by using the specification in Equation 1. Regression coefficients are expressed as New Zealand Dollars in thousands. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.3: Impact of Extratropical Cyclones on Firms' Business Equity (Standardized Coefficient)

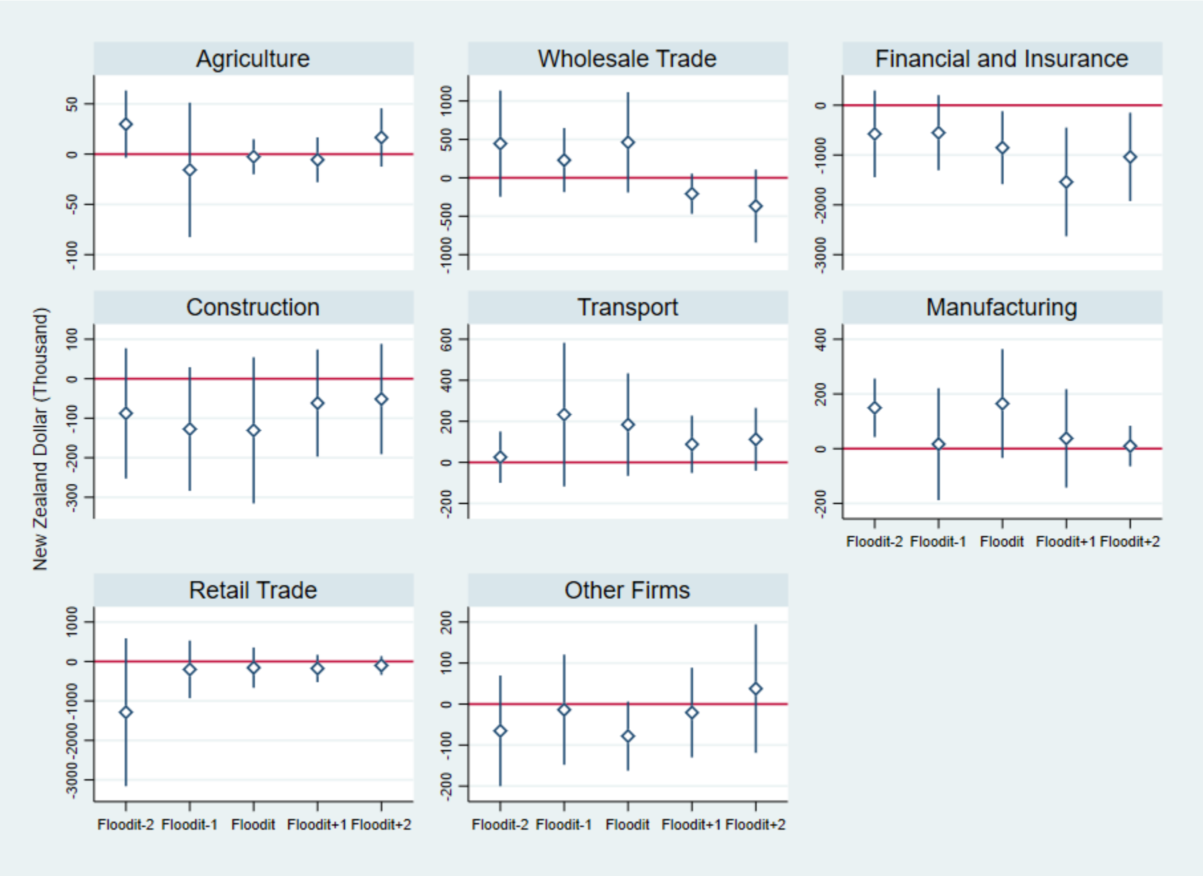


Note: The figures indicate the point estimates of the impact of extratropical cyclones (occurred during FY2018) on firms' business equity by using the specification in Equation 1. Regression coefficients are expressed as standardized coefficients. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.4: Flood-Affected Meshblocks in New Zealand

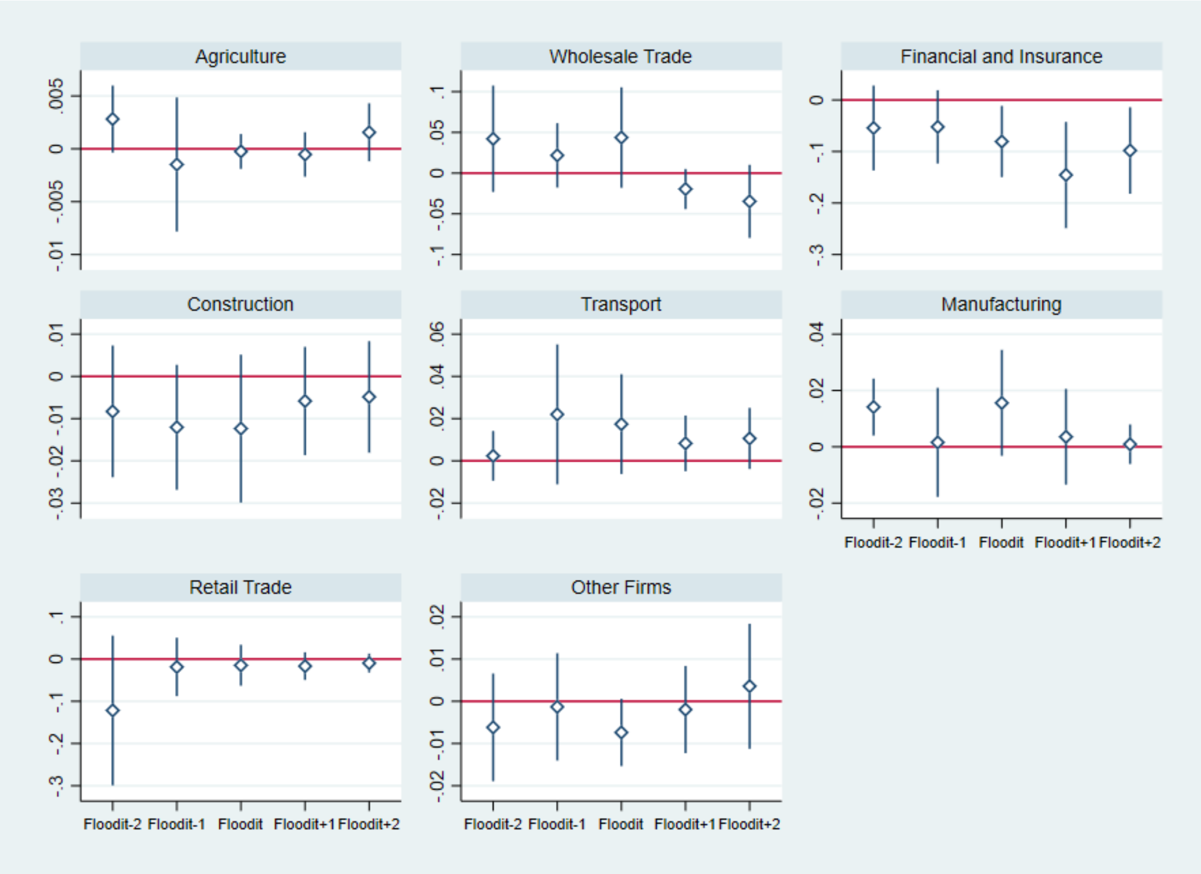


Appendix Figure 4.5: Impact of Floods on Firms' Profit (Absolute Coefficient)



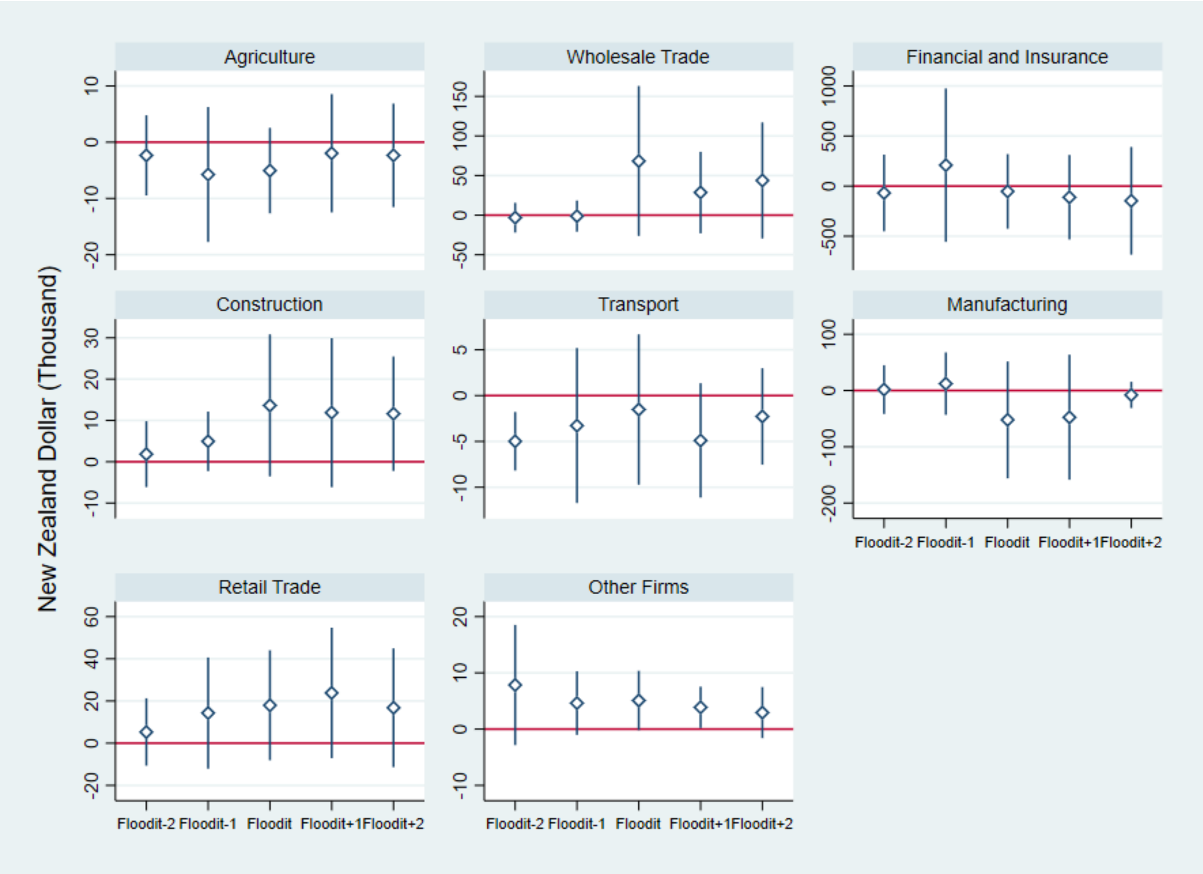
Note: The figures indicate the point estimates of the impact of floods on firms' profit by using the specification in Equation 2. Regression coefficients are expressed as New Zealand Dollars in thousands. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.6: Impact of Floods on Firms' Profit (Standardized Coefficient)



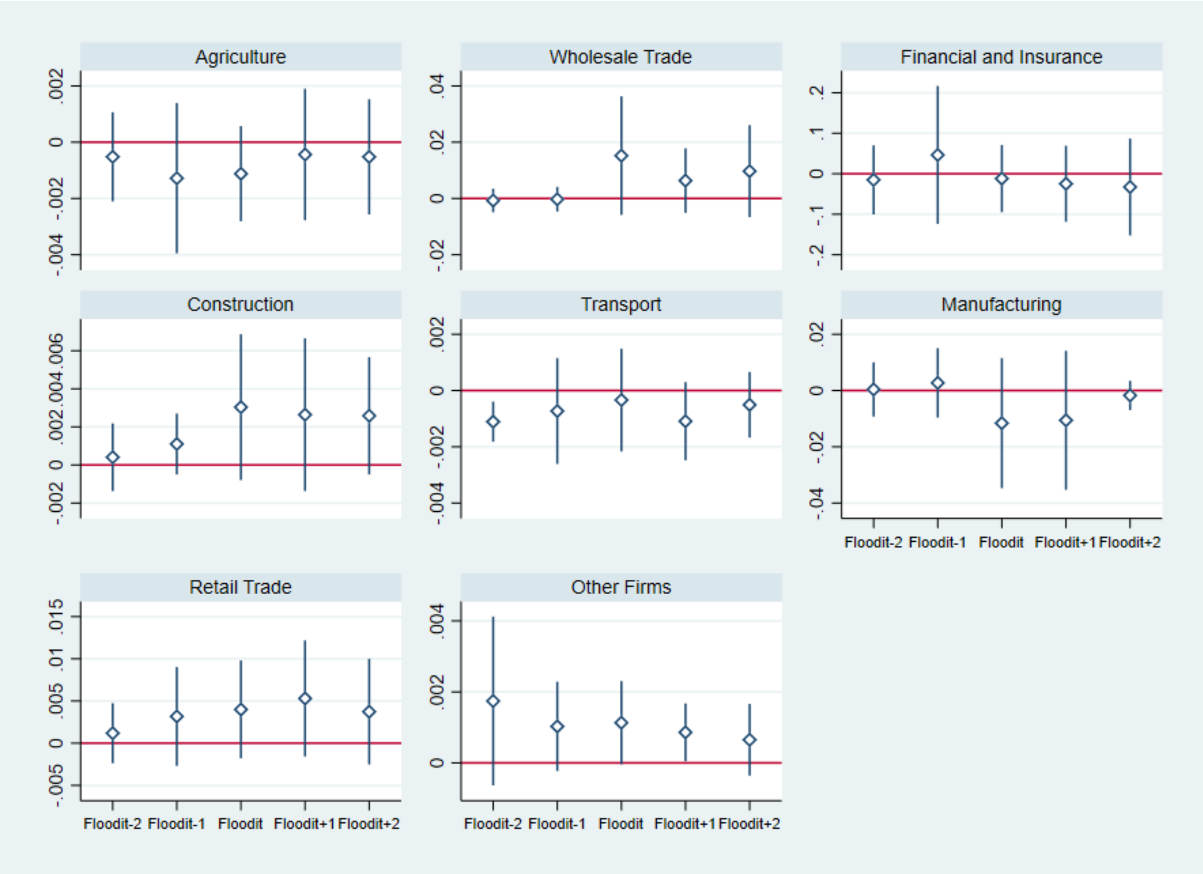
Note: The figures indicate the point estimates of the impact of floods on firms' profit by using the specification in Equation 2. Regression coefficients are expressed as standardized coefficients. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.7: Impact of Floods on Firms' Business Equity (Absolute Coefficient)



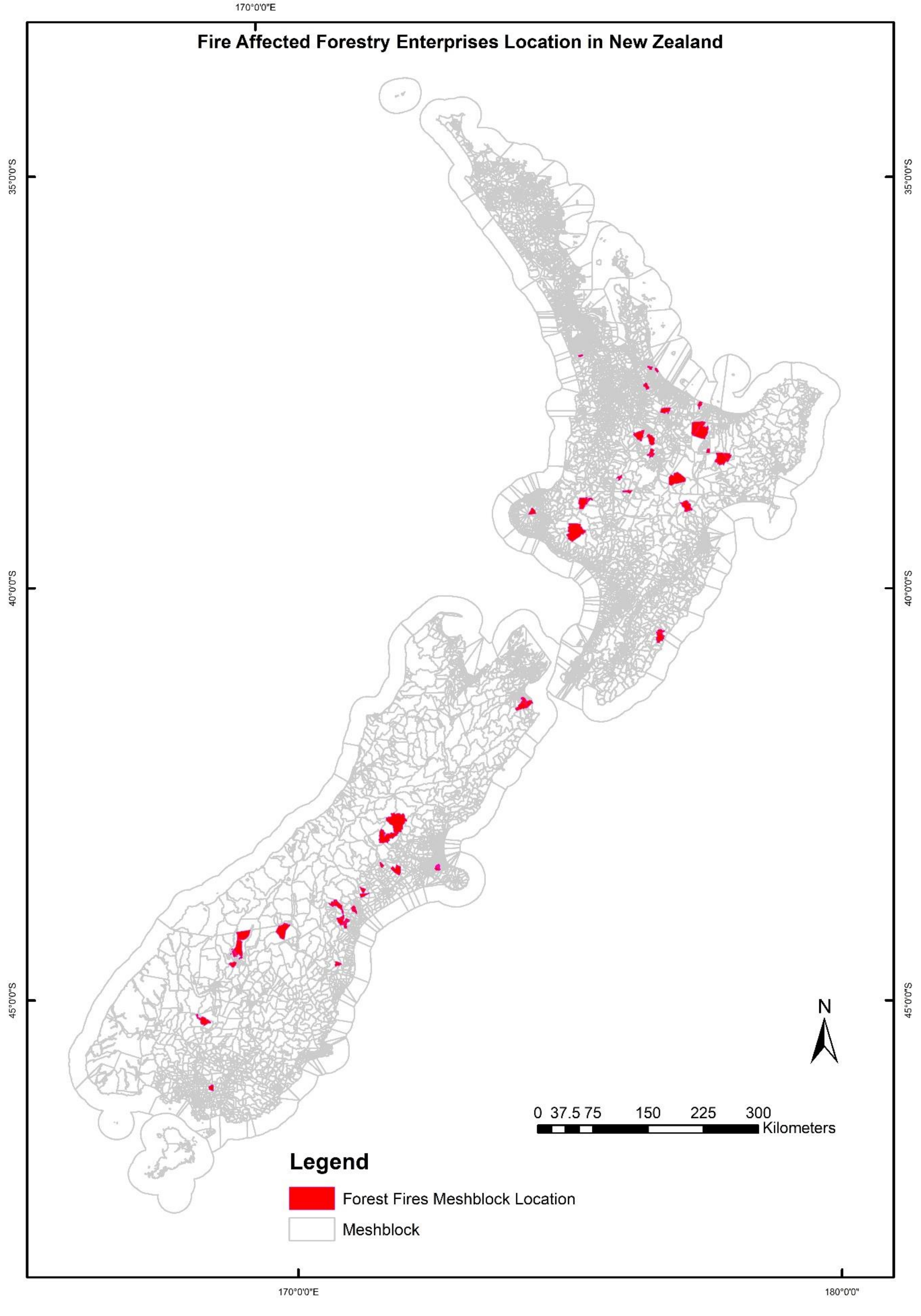
Note: The figures indicate the point estimates of the impact floods on firms' business equity by using the specification in Equation 2. Regression coefficients are expressed as New Zealand Dollars in thousands. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.8: Impact of Floods on Firms' Business Equity (Standardized Coefficient)

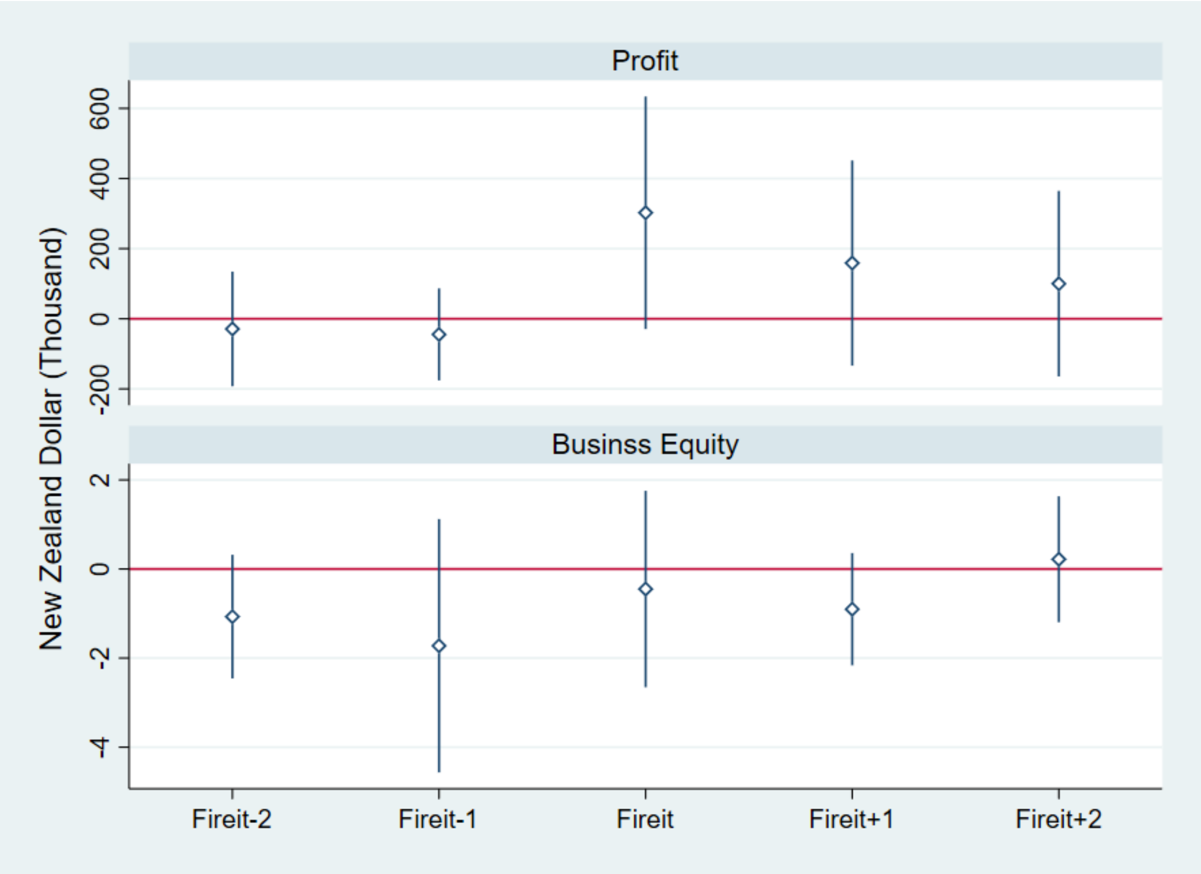


Note: The figures indicate the point estimates of the impact of floods on firms' business equity by using the specification in Equation 2. Regression coefficients are expressed as standardized coefficients. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.9: Wildfire-Affected Meshblocks in New Zealand

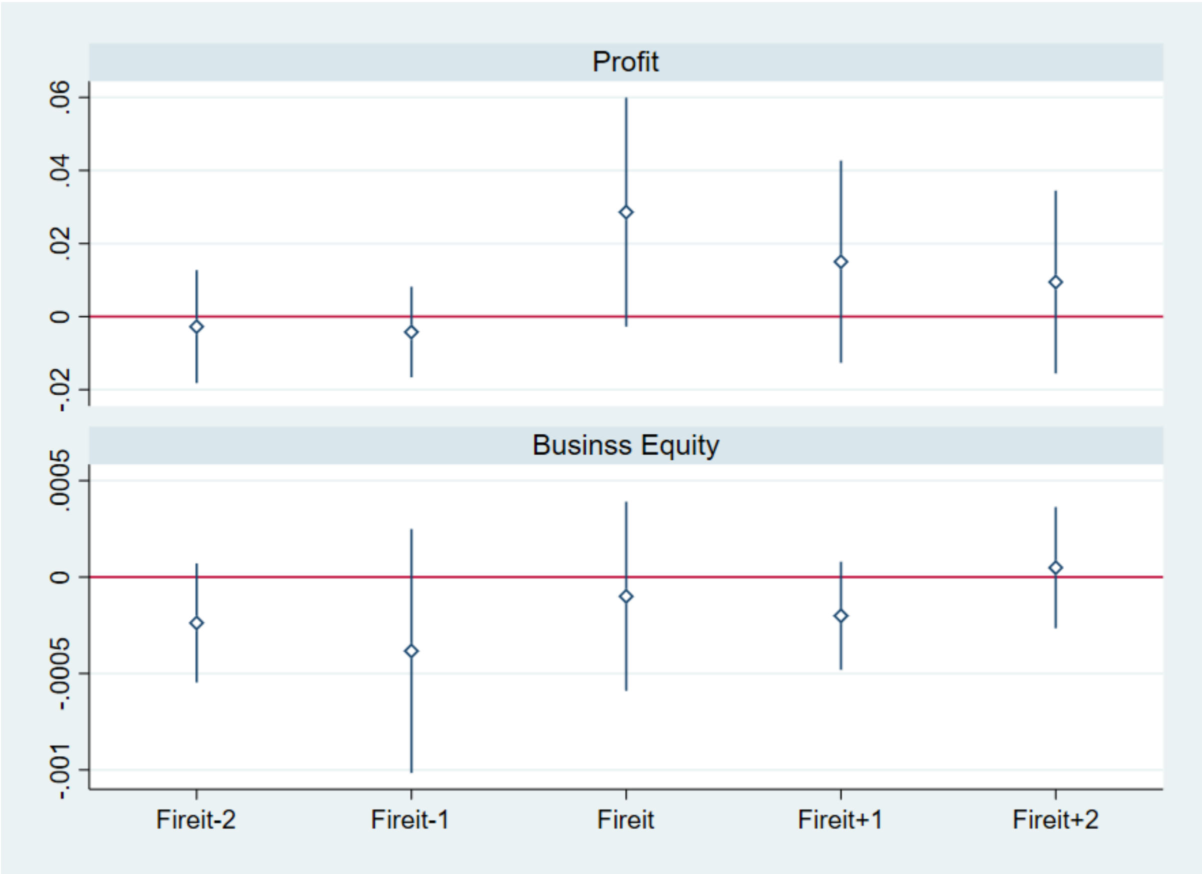


Appendix Figure 4.10: Wildfires and Forestry Firms' Profit and Business Equity (Absolute Coefficient)



Note: The figures indicate the point estimates of the impact of wildfires on forestry firms' profit and business equity by using the specification in Equation 3. Regression coefficients are expressed as New Zealand Dollars in thousands. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

Appendix Figure 4.11: Wildfires and Forestry Firms' Profit and Business Equity (Standardized Coefficients)



Note: The figures indicate the point estimates of the impact of wildfires on forestry firms' profit and business equity by using the specification in Equation 3. Regression coefficients are expressed as standardized coefficients. Each regression is adjusted for firm and year-fixed effects. Robust standard errors adjusted for clustering at the firm level. 95 percent confidence intervals are shown for each point estimate.

CHAPTER FIVE : CONCLUSION

This thesis aims at providing deep insight into the economic impact of extreme weather events on individual income and business firms' profitability in New Zealand. The three substantive chapters in the thesis empirically investigate the impact of extratropical cyclones and floods on individual incomes and the impacts of extratropical cyclones, floods, and wildfires on firms' profit and business equity. The findings and implications of the empirical studies included in the thesis are summarized below.

In Chapter 2, we empirically examine the impacts of extratropical cyclones on individual incomes (salary and wages, benefit and compensation, and self-employment) in the cyclone-affected regions. We find that individual income from wages and salaries declines by, on average, NZD 555 in the cyclone-affected regions compared with the non-affected areas. The findings also indicate that cyclones have no significant impact on individual income across different income groups. The findings of the chapter provide an in-depth insight into the microlevel impact of extratropical cyclones on individual income in New Zealand.

Chapter 3 focuses on the economic impact of floods on individual incomes in New Zealand. Flood is one of the costliest and most frequently occurred extreme weather events in New Zealand. After estimating the various panel regression specifications, the findings of the chapter show that, despite the large floods-induced privately insured damages, on average, floods had no statistically significant impact on the wage and salary, and total income of the individuals residing in flood-affected areas. In addition, the results also indicate no statistically significant impact of floods on the incomes of the above-median and below-median income groups and different individual groups based on gender, ethnicity, and educational qualification.

Chapter 4 estimates the firm-level impacts of extratropical cyclones, floods, and wildfires in New Zealand. We show that extratropical cyclones negatively affect the annual profit of agriculture, wholesale trade, financial and insurance services, and transportation firms compared with the unaffected firms during the cyclone year. However, we find cyclones have no impact on business equity across all firms. The results also provide statistical evidence that financial and insurance firms experience the worst impact of the cyclones compared with the rest of the affected firms. The estimated results find no statistically significant impact of floods on the profit and business equity of all firms under study. Similarly, we find that wildfires have no significant impact on forestry firms' profit and business equity.

The chapters in this dissertation cover only some of the possible impacts of these natural hazard events that could plausibly be estimated using the IDI and the LBD. For example, future research could use the data and methodology used therein to examine whether cyclones and floods affect the health status of the Aotearoa's residents. The IDI includes very detailed health records; and it is plausible, for example, that the incidence of stress-related health issues increase in the aftermath of flood or cyclone events. Alternatively, a future study could look at the impacts of cyclones and floods on individuals employment status and their long-term labour market participation. Finally, future work could measure the effects of cyclones, floods, and wildfires on the sectoral gross value added of firms operating in different economic sectors in New Zealand.

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