New Zealand firm investment following the Canterbury earthquake sequence

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Abstract

This paper investigates the economic effect of the 2010/2011 Canterbury earthquake sequence on New Zealand firm investment in the short-to-medium term. Almost a decade since the first quake in September 2010, the Canterbury economy has been reasonably resilient to the impact of the earthquakes; however, the real repair and rebuild activities might still exist for some specific industries. Using the disaggregated level data of New Zealand firms spanning over the period 2000-2018 in a difference-in-difference approach, this paper quantifies the impacts of these earthquakes on business in the region, paying an attention to heterogeneity in firm-level outcomes. Our findings show that the average annual investment ratio of Canterbury firms since 2010 is 2.2% higher than the nationwide, ceteris paribus. The results are driven by the impacts on manufacturing and construction sectors, followed by services industries. This pattern is supported by the expansion in firm assets and fixed assets in the region in addition to the potential channels in which those firms could use to mobilize funding for the reinvestment, including insurance claims, debt, shareholder funds, and government subsidy. Besides, conditional on firm survival, the average treatment effect seems to be significantly larger for surviving firms while non-productive firms might reduce their investment before their exits.

JEL codes: D22; D25; G31; L11; Q54

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1. Introduction

In late 2010 and early 2011, Canterbury endured a couple of major earthquakes which were seen among the most damaging natural hazard events in New Zealand's written history. Monetary damage was estimated at around 8% of GDP while the rebuild cost was even higher, roughly equivalent to 20% of GDP (Treasury, 2013). Both Repair and rebuild activities might have been accelerated for nearly a decade. To date, the Canterbury economy has been reasonably resilient to the impact of the earthquakes.

Regarding the macroeconomic consequences of disasters, some relevant works are presented in the literature. Overall, disasters cost lives and destroy infrastructure, buildings, plants, machinery and therefore affect both labour and capital. These events do not only disrupt the business operations of firms directly affected by the shocks but also influence the business activity of non-affected firms through upstream and downstream supply connections. Although the empirical findings from cross-country studies exploring the macroeconomic impacts of disasters are mixed, a major destructive disaster like an earthquake or a flood generally suggests replacing destroyed capital and updating technology play a positive role in the recovery (Skidmore and Toya, 2002; Okuyama, 2003; Kahn, 2005; Stromberg, 2007; Toya and Skidmore, 2007; Cuaresma et al., 2008; and Sawada et al., 2011).

Unfortunately, research studies examining the firm-level impacts of disasters are relatively scarce, especially in terms of physical capital accumulation and the persistence of the impacts over the medium term. Notable works are Leiter et al. (2009), De Mel et al. (2012), Hosono et al. (2016), and Basker and Miranda (2018). A literature summary is given in Table 1A (appendix). Leiter et al. (2009) show empirical evidence that the accumulation of capital stocks was significantly higher in regions affected by a major flood in Europe. Hosono et al. (2016) investigate the impact of banks' lending capacity on firm investment through the experiment of the Kobe earthquake in Japan in 1995. Their findings suggest that loan supply shocks affect firm investment. Basker and Miranda (2018) study the business survival and growth of Mississippi firms in the aftermath of the Katrina hurricane. However, these studies neither investigate the longer-term impacts of major disasters nor heterogeneity across industries. Also, to our best understanding, no empirical works to date provide the possible channels through which firms in affected regions could mobilize funding for their reinvestment in destroyed capital stocks.

The contribution of this study to the literature is thus twofold. First, the study is the first empirical analysis investigating the evolution of a destructive disaster over the medium-term using firm-level data. Second, the paper contributes to the literature by exploring the financial sources affected firms could use for reconstruction. We analyse the post-shock responses from firms' perspectives by applying a natural experiment of the Canterbury earthquake sequence that happened in New Zealand in 2010/2011 in a difference-in-difference approach. To be more specific, our questions first quantify the effect of these earthquakes on firm investment after almost a decade and further examine the heterogeneity of outcomes on several dimensions including sector, firm size, and survival, and the possible channels through which Canterbury firms could use to mobilize finance for their investment[1]. Our sample includes all New Zealand's private firms that recruited employment in the Annual Enterprise Surveys database, provided by the Statistic New Zealand covering the period from 2000 to 2018 as the latest year with the data available.

Our findings show that the annual investment rate of firms in Canterbury over the period 2010-2018 is on average 2.2% higher than that of New Zealand firms elsewhere, ceteris paribus. Likewise, the Canterbury firms appear to add 18.4% more fixed assets per annum than the nationwide; as a result, their total assets are 13% higher than the latter group, ceteris paribus. The results are driven by the impacts on manufacturing and construction sectors with the average treatment effects of 4.5% of 3.4% respectively, followed by services industries with an average impact of 2.7% while impacts on the primary sector do not stay robust across different specifications. The empirical evidence also suggests that medium-to-large firms invest more than small firms. Additionally, among firms in the region, firms invest more than the average treatment effect upon their survival as ceasing businesses appear to reduce their production. Regarding the financial sources for the reconstruction, apart from the insurance claims which seem to play an important role for the rebuild in the Canterbury region since 2010, other factors include the shareholder funds, debt, and government grants. Our estimates capture both direct and indirect impacts of the earthquakes on Canterbury firms.

The remainder of the paper is organized as follows. Section 2 presents the Canterbury economy and its earthquakes in 2010/2011, and Section 3 shows the data available. Section 4 describes the empirical specification, followed by the estimation results in section 5. Section 6 provides the discussion and conclusion.

2. The Canterbury economy and its earthquake sequence in 2010/2011

2.1. Canterbury economy in the 2000s

Prior to the earthquake sequence, Canterbury – the third largest region was home to about 12% of New Zealand's population and accounted for roughly 12.6% of the total GDP in the national

[1] Several works present the post-quakes market and business responses and resilience following the Canterbury earthquakes (Fabling et al., 2014; Inland Revenue, 2015) with more details in Table 1A. However, these studies focus on short-run responses of the Canterbury economy. Thus, we have the motivation and advantage of being able to examine the dynamics of recovery over a longer time horizon.

economy (Figure 1). The region's average annual growth rate in real GDP per capita over the 2000s was 1.99%, a little higher than the national growth rate of 1.59%. The real income per capita of Canterbury in 2009 was 36,104 $NZ, compared with the average number of 40,208 for nationwide (Figure 1, Statistics New Zealand).

In terms of sectoral contribution to the Canterbury economy in the 2000s, construction accounted for 6.3% of its GDP, followed by the primary sector with 8.8% of GDP, manufacturing with 13.7% of GDP, and other services sector as the largest contributor (71.2% of GDP). This pattern was relatively similar with nationwide over the same period (Figure 2). Tourism is also an important sector, with many tourists visiting Christchurch prior to the earthquakes to enjoy the scenery created by the Southern Alps. Christchurch city was the location of a few important services with a hospital, university, and art gallery and sports facilities (Potter et al., 2015).

The average investment rate of Canterbury firms in the 2000s was 20.6%, in comparison with 20.4% in Waikato and 20.7% nationwide. The region followed a similar pattern in firm investment relative to the national economy (Figure 3). A few years before the global financial crisis and just prior to the earthquake sequence, Canterbury's economic growth rates were as close as those of New Zealand (Figure 4).

2.2. Summary of the Canterbury earthquake sequence and its impacts

A magnitude 7.1 earthquake struck the Canterbury region of New Zealand at 4:35 am on September 4th, 2010. It was centred at the rural town of Darfield; Christchurch City, the second biggest city in the country, lies 40 km east of Darfield and was home to a population of approximately 370,000 at the time of the earthquake. There was extensive damage to buildings and infrastructure, approximately 100 people were injured but no recorded deaths. Then, on February 22nd, 2011, an M6.3 aftershock occurred 5 km south-east of Christchurch at a depth of only 5 km. This earthquake struck at lunchtime on a working day, causing catastrophic damage to the city and 185 deaths (Potter et al., 2015). Most of these casualties occurred as a result of the collapse of two large office buildings, with further deaths resulting from falling bricks and masonry, and rockfalls in city suburbs. Although the Canterbury region continued to experience aftershocks, and some of the considerable size, the two earthquakes in September 2010 and February 2011 caused most of the major damages to land, property, and infrastructure.

The Canterbury earthquake sequence caused severe impacts on the economic, built, social, and natural environments in the region. Many buildings were severely affected and damaged by ground shaking and deformation, including liquefaction, uplift, subsidence, and tilting. Those damaged properties included residential housing, health care, and schooling facilities, the central business district, iconic landmarks, and heritage buildings. Also, the earthquakes have impacted individuals, whanau, social networks, and communities in many complex and interrelated ways. The natural environment in the region was significantly affected, including liquefaction, lateral spread near waterways, land level changes, and numerous rockfalls and landslides (Potter et al., 2015).

The Treasury of New Zealand (2014) estimated that the total investment associated with the rebuild would be around NZ$40 billion[2] (roughly 20% of GDP). After the second earthquake, on March 10th, the Reserve Bank of New Zealand lowered the official cash rate from 3% to 2.5%. This was done to lessen the economic impact of the earthquake since there was considerable damage done to infrastructure and buildings, disruption to business activity, and a likely deterioration in consumer and business confidence. Inflation, however, remained within the medium-term target (Reserve Bank of New Zealand, 2011, and 2016).

Regarding the impacts of the earthquake sequence on firm allocation by industry, about 10% of primary industry firms were represented in the high impact intensity areas while manufacturing, construction, trade, and other services were almost all overrepresented in the heavily affected areas with more than half of the firm share[3]. Regarding the firm scale, just over half of the small firms were in the high impact intensity areas while that share was almost 60% for medium and large firms (Fabling et al., 2014).

3. Data

The most important source of data is from New Zealand's Longitudinal Business Database (LBD), maintained by Statistics New Zealand as part of the Integrated Data Infrastructure (IDI). To mitigate the possible selection bias, our sample includes all New Zealand's private-for-profit firms that recruited employment in the Annual Enterprise Surveys (AES) database from the LBD. As a result, this study includes 301,527 firms in New Zealand covering the period from 2000 to 2018 as the latest year with the data available. We also provide some sensitivity analysis regarding the sample selection.

Outcomes are measured at the aggregate firm level, rather than the plant level because the former is the filing unit, and within financial years which start from 1st of April to 31st of March in the following year. Thus, the two major earthquakes are defined to happen in the financial year 2010 in this paper (they occurred in September 2010 and February 2011).

The primary outcome variable of interest is investment rate which is measured by the ratio of gross fixed capital formation during period t to capital stock at the end of period t-1. This ratio is widely used in empirical studies about investment based on the Q theory. The mean and standard

[2] Including residential property ($18b), commercial property ($9b), and infrastructure and social assets ($11b).
[3] Fabling et al. (2014): High impact intensity areas are meshblocks with at least half of the eligible firms receiving the earthquake support subsidy (ESS).

deviation of this outcome is 0.136 and 0.448 with a historical distribution given in Figure 5. Figure 3 depicts the investment patterns of firms in Canterbury and nationwide over the period in question from 2000 to 2018. Before the global financial crisis, the investment rate in New Zealand was relatively high at just over 20%, followed by a sharp decrease in 2009 and 2010, and gradually rose since 2011 (Figure 3). The national economy, therefore, experienced negative growth rates from the last quarter in 2008 until the first quarter in 2010 (Figure 4). Also, the Canterbury region's investment and GDP growth rates were relatively similar to those of the nationwide just before the earthquake sequence (Figures 3 and 4).

Other outcome variables include total assets, total addition in fixed assets, equity, and total debt, all in logged terms for handy interpretation and reducing variation in these variables. The last outcome variable is the debt ratio which is defined as the ratio of total debts to total assets. Tables 1 and 2 provide more details about the construction and statistical description of these variables; Figures 6 shows their historical distributions.

As an explanatory variable, subsidy - "sub" is a binary variable taking the value of one if firms receive government grants and/or subsidy in the year[4]. To estimate the heterogeneous effect of the earthquakes conditional on firm survival, the variable "ceasing" is defined as another binary variable taking the value of one if firms cease from the timing of the first major quake, or September 2010.

Firm size is defined by the classification of MBIE (2017) as one of four categories based on firms' full-time employees (FTE); particularly, micro firms include firms with less than FTE; small firms include those with FTE in the range [5; 20); medium firms include those with FTE in the range [20; 50); and large firms capture those with 50 FTE or more. Specifically, micro firms account for 79.9% of the total firm number in the sample, followed by 15.5% small firms while there are only 2.3% medium firms and 2.3% large firms (Table 2).

Other variables as the controls include parent, branch, firm age, and entering, followed by the relevant literature examining the determinants of firm growth (i.e., Evans, 1982; and Sutton, 1997). Tables 1 and 2 provide more details about the construction and statistical description of all variables used in this study. We only include the time-invariant controls as they are not affected by the earthquakes, except "entering" provided the structure of New Zealand with a moderate representation of entry firms. "Entering" is a dummy variable taking the value of one for the year of entry and the following year. "Parent" and "branch" are two other dummies indicating values of one if firms have parent enterprise and at least two locations. "Firm age" is a continuous variable

[4] Unfortunately, we are unable to access the Earthquake Support Subsidy data.

in logged terms. For the only purpose of comparison, some estimations control for the time-variant financial variables which are known as important determinants of firm investment, including profitability or profit-to-asset ratio, sale growth, and liquidity or current assets to total assets ratio with one lag. However, our interpretations do not rely on these estimations as these financial variables are also affected by the earthquakes.

All dependent variables and other financial variables are obtained from the AES while other variables identifying firm characteristics including enterprise registered number, "parent", "branch", "firm age", and "firm size" are from the Longitudinal Business Frame as part of the IDI. The last control variable is "drought" accounting for the impact of the 2012/2013 drought that might affect the treatment outcomes, using the potential-evapotranspiration-deficit (PED) data from the Ministry for Environment. The "drought" variable is defined as the percentage change in PED in 2012 or 2013 relative to its corresponding value in 2011 while it equals zero in all other years.

4. Empirical specification

We apply the difference-in-difference approach to examine the responses in Canterbury firm investment to the earthquakes which were exogenous, and unanticipated to corporate activities. The estimating equation is as follows:

$$\text{investment}_{i,t} = \alpha + \beta\,\text{Can}_i + \mu\,\text{post}_t + \pi\,\text{Can}_i * \text{post}_t + \text{X}_{i,t} + v_t + \varepsilon_i + r_i + u_{it} \quad (1)$$

where $\text{investment}_{i,t}$ is the investment ratio of firm i in year t; Can_i is a dummy variable taking a value of one for Canterbury firms and zero otherwise; post_t is another dummy variable taking a value of one for all years from 2010 to 2018; $X_{i,t}$ denote the set of control variables, including parent, branch, firm age, and entering. These control variables are in line with the results in the relevant literature examining the determinants of firm growth (i.e., Evans, 1982; and Sutton, 1997). We also include year fixed effects (v_t) to capture the economic conditions changing over time, and firm fixed effects (ε_i) and territory fixed effects at district levels (r_i) to account for the other time-invariant factors and regional features determining investment patterns across firms.

As we aim to capture both direct and indirect impacts of the Canterbury earthquakes on firm investment, the treatment group includes all Canterbury firms. Regarding the selection of the control group, we first use all New Zealand firms elsewhere as the baseline. Our earlier analytics shows the similarities in economic performance and sectoral structure between Canterbury and New Zealand as a whole (section 2). Figures from 1 to 4 further support our choice for the control group. We also use Waikato as the alternative control group as firms in this Northern region are unlikely to be affected by the earthquakes while showing the similar economic development and sectoral structure to the Canterbury region, particularly with the significant contribution of the agricultural sector. Indeed, Canterbury is the third largest region while Waikato is the fourth largest one in New Zealand. Our t-tests also support the choice for these control groups as we do not find any statistical significance of the difference in investment outcomes between the treated and non-treated firms.

5. Estimation results

5.1. The average impact on Canterbury firm investment

Table 3 reports the average impacts of the Canterbury earthquake sequence on firm investment in the medium term. Particularly, the average annual firm investment in the Canterbury region is 2.2% higher than that of New Zealand firms elsewhere, holding for other things fixed (column 4). This is the result of the expansion in capital stock for the rebuilding following the major quakes. Our estimates capture the average treatment effects, both direct and indirect. The direct impacts are from the damaged firms in the region while the indirect ones represent the sound investment environment in the whole region regardless of monetary damages.

In addition to the estimation of the average earthquake effect over the post-quake period, we are also interested in the dynamic evolution of the effect and, therefore, estimate our specifications for different points in time since 2010. The immediate estimate is just 1.6% in 2010 and the impacts increase significantly over the course of the next three years before falling since 2015. It explains the emergent need for finance for the rebuilding from 2012 to 2014 with the peak in 2012. Our estimates seem to be quite consistent with the economic growth pattern in the region (see Figure 4). Specifically, the rapid expansion in capital stocks in Canterbury contributed to the high economic growth rates from mid-2012 to early 2015 in comparison with the national performance. Since the second major quake in February 2011, the government continued its low-interest rate policy to aid the recovery and the rebuilding. Simultaneously, there was a rapid increase in imports into New Zealand as the small open economy might have relied on imported materials. Imports immediately increased, followed by an expansion in the trade deficit. Our results are in line with the relevant literature exploring the impacts of a major destructive disaster which generally suggests replacing destroyed capital and updating technology play a positive role in the recovery, from either aggregate levels (Skidmore and Toya, 2002; Okuyama, 2003; Kahn, 2005; Stromberg, 2007; Toya and Skidmore, 2007; Cuaresma et al., 2008; and Sawada et al., 2011) or disaggregate levels (Leiter et al., 2009; Hosono et al., 2015; and Basker and Miranda, 2018).

For the specifications without any control variables, the average effect is somewhat higher as the estimate is likely to subject to omitted variable bias (column 1). The control variables show results consistent with our expectations. The negative and statistically significant coefficients of the variable age prove that young firms appear to invest more relative to old cohorts. A large proportion of micro firms and small firms is a typical feature of the New Zealand economy and it is reasonable to anticipate new firms to invest more at the beginning years. Our estimates for the variable entering show that pattern. The anticipated coefficients on those control variables are in line with the results in the relevant literature examining the determinants of firm growth (Evans, 1982; and Sutton, 1997).

Our interpretations do not rely on the estimations controlling for the time-variant financial variables which are known as important determinants of firm investment as they are affected by the earthquakes. However, we also include some controls including profitability, sale growth, and current assets to total assets ratio with one lag. The regressions with these additional controls exhibit somewhat larger estimates which are provided upon request.

5.2. Heterogeneity across Canterbury firms

5.2.1. Sector

Industry is a potential dimension over which the outcomes may differ. According to our estimation results, manufacturing and construction are two sectors experienced the highest impacts on firm investment, followed by other services sector while the impact is the least significant in primary industries (Table 4). Specifically, the average impact is 4.5% for manufacturing, 3.4% for construction, 2.7% for other services, and 1.6% for the primary sector. Our estimates are explained by the distribution of the monetary damages across different sectors. In addition to this, those heterogeneous impacts might be explained by the difference in investment patterns across sectors before the earthquakes. Particularly, over the period 2000-2009, the average investment rate was observed to be the highest in the construction sector (around 28%), followed by the services sector (25%) while it was just around 20% in the manufacturing sector[5]. Regarding the dynamic evolution of the effect, manufacturing and construction sectors only experience significant impacts until 2014 while other services sector observes the persistent impacts until 2018. Retail trade, accommodation, cafes and restaurants, and the business services group of industries were in the heavily affected CBD (Fabling et al., 2014). Likewise, since the quakes, there has been a larger increase in GST on turnover in Canterbury than nationwide, notably in construction, manufacturing, and other services including retail; electricity, gas water and waste; real estate; financial & insurance; professional, scientific and technical services (Inland Revenue, 2015). The shock persistence observed might reflect the indirect impacts of the earthquake sequence that

[5] In our difference-in-difference approach, the average treatment effect represents the relative difference in the outcomes between the treatment and control groups, in the post- and pre-periods. Investment in manufacturing was lower in the pre-period in comparison to construction sector, we expect the higher impact of the earthquakes on the former sector.

appear to be more prolonged than the direct impacts, for instance enhancing the medium-term investment environment.

There is only a temporary impact on firm investment in primary industries given the sector was the least affected. Although we control for the territory fixed effects, it is notable to mention that the 2012/2013 drought might have affected the outcome variable during the post-treatment period, especially for the agricultural sector. As a result, the regression adding that drought variable shows a smaller coefficient for the primary sector (which is 1.4% only, see column 2 of Table 4) while we do not find significant impacts of the 2012/2013 drought on firm investment in other sectors.

5.2.2. Firm size

We also examine the impacts of subgroups by simultaneously considering heterogeneity in firm size, classified by employment level in Table 5. We follow the firm size classification from the MBIE (2019) to create three dummy variables to denote the four different categories including micro firms, small firms, medium firms, and large firms (where large firms are the reference group in the regressions). The average estimates for micro firms and small firms are only 1.7% and 1.1% respectively (columns 1 and 2). Though micro and small firms represent 96% total firm number in New Zealand, they only hold roughly 20% of the total assets. According to our estimations, bigger firms appear to experience higher impacts on investment. This partially explains the fact that the share of medium and large firms located in the high impact intensity area is somewhat higher than that of small firms. Importantly, large firms can find it more easily to mobilize finance for investment relative to small firms, i.e., from raising shareholder funds, borrowing, or asking for financial assistance from parent companies. Basker and Miranda (2018) also find that larger and more productive firms had an advantage in rebuilding their operations quickly and hired more workers following the Katrina Hurricane in 2005, conditional on survival.

The results seem to be robust once we break the whole sample into subgroups by sector, except in the case of the primary sector. We no longer find the significant impact of the earthquake sequence on primary industry firms based on their size. It is worth referring to the fact that only 10% of the primary sector firms were represented in the high-impact intensity area.

5.3. The average impact on firm assets and fixed assets

Regarding the responses in firm total assets, our estimations reveal that the average growth in total assets of Canterbury firms is 13% higher than that of an average New Zealand firm, ceteris paribus (Table 6, column 1). The impact is much bigger for the construction sector where the total assets of the treated firms grow faster by 22% than their counterparts (column 7). The remaining sectors including primary industry, manufacturing, and other services exhibit a little smaller impact than the average treatment effect of 13% (Table 6). These impacts on total assets further shape a consistent picture with the earlier estimates on investment ratio, our main variable of interest, and are in line with the findings from Leiter et al. (2009). Particularly, they find evidence that, in the short run, European firms in regions hit by a flood show an average higher growth of total assets than firms in unaffected regions. Furthermore, we find the marginal impacts on firm asset growth increase from 2010 to 2014 and start to decline gradually to 2018, and persistent impacts are observed in all sectors. This explains the rebuilt pattern following a severely destructive disaster when affected firms demand to expand physical capital stock in the short-to-medium term. The heterogeneity across different sectors might be due to their shares of total assets and capital stock, for instance, the share of capital stock in the construction sector is relatively small (3.4%) than that of other sectors (16.8% for manufacturing, 32.7% for primary sector, and 47% for services sector)[6].

To further understand the rebuilding pattern following the Canterbury earthquake sequence, we investigate the change in fixed assets of firms in the region. Table 7 provides the results. Particularly, the average growth in addition to fixed assets of Canterbury firms is 18.4% higher than that of an average New Zealand firm, ceteris paribus (column 1). The impacts on addition to capital stock turn out to be quite analogous to those on capital stock, though somewhat larger. Construction firms in the Canterbury region report the growth rate of addition to fixed assets 35.6% higher than the average rate of New Zealand firms elsewhere while the impacts on other sectors remain relatively close to the average treatment effect of 18.4% (Table 7). Again, firms in the region appear to rapidly expand their capital stock for the rebuilding until 2014 before reducing their marginal rate of fixed assets expansion until 2018.

5.4. Possible channels for Canterbury firms to raise investment

5.4.1. Insurance claims

New Zealand is a country highly exposed to earthquake risks and (re)insurance has been playing a significant role in the rebuild and recovery of the country following the Canterbury earthquakes. As of March 31st, 2018, all insurers including the EQC had paid NZ$ 34.6 billion in Canterbury earthquake claims with an estimate of the total ultimate incurred claims to be NZ$ 36-39 billion (Reserve Bank of New Zealand, 2018). This estimated number is quite close to the estimated cost of reconstruction projected by the Treasury of New Zealand; however, it is hard to verify the share of insurance claims used for the rebuild following the Canterbury earthquakes. Interestingly, the paid insurance claims have increased significantly following the second major earthquake until the

[6] This observation is still applicable when accounting for the firm number, i.e., the share per firm in each sector.

end of 2015 before slowing down in later years (Figure 5). Reserve Bank of New Zealand (2011) estimated large global reinsurers contributed about two-thirds of the total insurance claims (there is no domestic reinsurance market). Thus, those insurance claims might have contributed not only to the rebuild of the affected firms in Canterbury but also to the sound investment environment in the region in some indirect ways, i.e., through the claims on the damaged houses and other residential properties. Also, the insurance payouts are likely to interpret some exogenous variation in Canterbury firm investment following the earthquakes.

Countries vulnerable to disasters may already have in place preventive measures, including emergency funds, contingent credit lines, insurance and reinsurance policies, catastrophe bonds (e.g., available to the Pacific Alliance), and other financial instruments to absorb the shock. Among the earthquake-affected countries, the quake-prone group experienced more severe events compared to other regions. Japan, New Zealand, or Chile have and will continue to be hit by more severe earthquakes than European countries. As such, ex-ante, the quake-prone countries in the high-income group like Japan, New Zealand, Greece, Italy, and the United States have well-developed financial markets, through which disaster risks can be transferred to the capital markets, or through insurance and international reinsurance. New Zealand provides a good example following the Canterbury earthquake in 2011. The disaster insurance coverage is over 95% for residential buildings in New Zealand, and international reinsurance covered about half of the losses from the Canterbury earthquake. The central bank deployed a low interest-rate policy to facilitate economic recovery and growth while keeping the medium-term inflation target. Japan, however, has much lower insurance coverage with a relatively low rate of international reinsurance (Ito and McCauley, 2019; Nguyen and Noy, 2020). To a lesser extent, it is undeniable to affirm the role of insurance for rebuilding following a destructive disaster in high-income economies.

5.4.2. Equity and debt

We find empirical evidence that Canterbury firms mobilize finance for their investment through equity and debt channels (Table 8). The supporting role of firm equity seems to be significant. Our results reveal that the average growth in equity of Canterbury firms is 17.8% higher than that of an average New Zealand firm, ceteris paribus, and the impacts are persistent over time (column 1).

Regarding the debt channel, columns 3 and 4 show the average growth in total debt of Canterbury firms is just 4% higher than that of an average New Zealand firm, ceteris paribus while there is so significant impact until 2013. These regressions might be subject to a selection bias as zero-debt firms are typical in the New Zealand economy (those firms are omitted after taking the natural logarithm of total debt). Another feature of the debt structure in New Zealand is such a fact that long-term debt accounts for most of the firm debt. Hence, we alternatively use binary variables to examine the probability of being indebted in the treated firms. We still find empirical evidence that firms in the region are more likely to be indebted in comparison with other firms elsewhere. Because debt and probability of survival following a major shock might be related to each other, we further delve into the heterogeneity conditional on firm survival. Interestingly, we find surviving firms in Canterbury are likely to use debt as a channel for investment while ceasing firms appear to reduce their debt. We find analogous results when assessing the probability of Canterbury firms having funded by long-term debt[7]. These estimates turn out to be in line with our later results when analysing the heterogeneous impacts of the earthquakes on firm investment upon their survival (section 5.5.3 provides further discussion). Our results are consistent with the earlier findings from Inland Revenue (2015) illustrating that debt as a share of turnover from Canterbury firms increased relative to the average debt of a New Zealand firm in 2014 and 2015, observed in small and medium firms.

Regarding debt sustainability, column 5 of Table 8 shows that the average debt-to-asset ratio of Canterbury firms over the post-quake period seems to be smaller by 3.6% relative to the nationwide. The impacts on that debt ratio appear to persist over time since the first major shock (column 6, Table 8). These estimates might be driven by the fact that the positive impacts of the earthquakes on the total assets of firms in the region are likely to be larger and more persistent than those on firm debt. If the results assume that firms in the region seem to be more sustainable in using debt for their operations, it is more probable to observe that pattern from productive firms that could survive after the earthquakes.

5.4.3. Government subsidy

In difficult times, government grants and subsidy can support corporate operations. We are unable to assess the role of the earthquake support subsidy, therefore, we use data on overall grants/subsidy from the government to figure out if Canterbury firms would mobilize those financial resources for their investment. We find empirical evidence that Canterbury firms receiving grants and subsidy seem to invest more than firms without support from the government, ceteris paribus (columns 7 and 8, Table 8). Likewise, De Mel et al. (2012) investigate the recovery of Sri Lankan firms following the 2004 tsunami and find that direct aid had a significant positive impact on the profits of the affected firms in the retail industry, but not in the manufacturing sector while grants helped those firms recover with a higher rate of capital stock than the control group.

[7] These results are being reviewed by Statistics NZ before being released. We will be presenting these estimates on the NZAE conference date, 23rd of June 2021. Alternatively, please contact us if you want to discuss or provide us your comments or suggestions.

5.5. Robustness and sensitivity analysis

5.5.1. Using Waikato as the control group

Our estimates remain robust shown in Table 9; in particular, the average treatment effect is around 2% (column 1), compared with the 2.2% impact in the baseline. Regarding the heterogeneous effect, manufacturing and primary firms show the largest average impact, followed by construction and services firms. There might have a reconsideration of the impact for the primary sector which is likely to be driven by the agricultural firms (columns 2 and 3). Due to the booming in the dairy sector in the past two decades, the average investments in the agricultural sector of Waikato and Canterbury are often higher than the national rate of New Zealand. As a result, in the pre-quake period from 2000 to 2009, Waikato's investment rate of 15.7% in agriculture is much higher than that rate in Canterbury (13.4%) and the average rate of the entire country (13.1%). However, over the period 2010-2018, the average investment rate in Waikato's agricultural firms reduces more significantly relative to other regions (see Figure 7). These patterns help explain the higher impact of the earthquakes on the primary sector when using Waikato as the control group, in comparison with the baseline estimate.

5.5.2. Placebo test assigning the earthquake sequence to the Waikato region

For the reasons mentioned above, we further testify the results by using Waikato in a placebo test in which that region is assumed to experience the earthquake sequence in 2010/2011 instead of Canterbury. Table 10 provides the estimation results. The first column presents the robustness of our baseline estimates in which the average treatment effect is not statistically significant. We also find no statistical evidence across industries when Waikato is the treated region, except the primary sector (columns 2 and 3). This pattern is explained earlier by the changing investment environment of Waikato's agricultural firms over the past two decades. When we drop Canterbury firms in the estimations, the results remain robust (columns 7 to 12).

5.5.3. Impacts conditional on firm survival

The Canterbury earthquake sequence might be considered as a natural selection to eliminate poor-performing firms in the region. We are thus interested in estimating the consequential effect of those shocks on firm investment conditional on their survival. Table 11 provides the estimation results. Specifically, surviving firms in Canterbury appear to increase their investment ratio by 4.5% per annum – ceteris paribus while poor performers in the region decrease their capital stock by 3.5% per annum in comparison with their unaffected counterparts. This pattern is consistent with the findings provided by Fabling et al. (2014) in which non-productive firms are disproportionately, and strongly selected to exit while surviving firms rapidly revert to status quo profitability levels. Additionally, the impacts on debt upon their survival discussed earlier are supportive in shaping this picture.

Among all affected firms ceased since the first major earthquake, their investment decreases in 2010 and starts to decrease more over time. Debt from these firms also follows the analogous pattern in which they need to pay their debt before terminating their businesses. Failing to mobilize debt for survival might be an explanation why those non-productive firms reduce to invest in capital stock. Regarding the heterogeneity across sectors, signals seem to be the most evident for ceasing firms in the services sector, followed by the construction and primary sectors while the manufacturing firms only show the pattern in recent years.

5.5.4. Dropping all micro firms with no more than one employee

For another sensitivity analysis, we drop all micro-firms which recruit on average no more than one employee over the period of question. Though the feature of New Zealand's economy is such a fact that those micro-firms account for almost 40% of the total firm number, they only hold 8% of the total New Zealand firms' assets. Our results illustrated in Table 12 appear to be robust when the average treatment effect is merely 2.1%. The average impacts relative to the baseline seem to be bigger for the three sectors including manufacturing, construction, and services while there is no significant impact observed in the primary sector.

6. Discussion and conclusion

This paper quantifies the effect of a major destructive disaster on capital stock accumulation over almost a decade utilizing a quasi-experiment of the Canterbury earthquakes. The empirical results regarding the macroeconomic consequences of disasters in the relevant literature might be mixed subject to different types of disasters and the outcomes of interest. It is more likely to observe the fact that a major destructive disaster like an earthquake or a flood could have positive impacts on investment over the medium run, rather than the case of a severe drought. It is worth discussing further the differential impacts of earthquakes and droughts on firm investment in our study. While the 2010/2011 Canterbury earthquakes increase investment for firms in the region, the 2012/2013 drought appears to have a negative impact on capital stocks across New Zealand. The former resulted in monetary damages in capital stocks which have been replaced while the latter did not. Instead, the severe drought in New Zealand in 2012/2013 caused difficulties in business operations especially for the agricultural sector which has been remaining an important contributor to the overall economic performance of the country. Also, the dynamic evolution of the effect from the Canterbury earthquakes might suggest that impacts of a destructive disaster might be likely to persist longer in services industries rather than other sectors in a developed country where the former sector contributes the most to its economic growth.

Our empirical results not only add to the public understanding about the ex-post responses of New Zealand firms following the Canterbury earthquakes but also quantify the need for financial resources for the rebuilding across sectors over almost a decade in New Zealand. The persistence of the effect and the heterogeneity in the outcomes might reveal some insights into firm resilience and the roles of different channels for financing the reconstruction in the case of future events, and that might be more plausible in high-income countries. Channels to mobilize finance for rebuilding following a major disaster might differ across countries and income groups. For instance, low-to-middle income countries might rely more on debt and government reserves than the high-income group. In the case of New Zealand, it is undeniable to affirm the important role of earthquake insurance for reconstruction. Future works could delve into the empirical evidence exploring the role of insurance claims toward firm investment after the Canterbury earthquakes.

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Tables & figures

Table 1. Variable description

Variable	Construction/description	Source
year	Financial year: starts from 1st of April to 31st March in the following year (counted to the start year)	Statistics NZ
investment	gross fixed capital formation/total fixed assets (I/K)	
ln(ta)	ln(total assets/gdp defaltor)	
ln(afa)	ln(addition in fixed assets/gdp deflator)	
ln(debt)	ln (total debt/gdp deflator)	
debt ratio	total debt/total assets	
ln(equity)	ln(total equity or shareholder funds/gdp defaltor)	
Can	=1 if Canterbury firm; 0 otherwise	
Wai	=1 if Waikato firm; 0 otherwise	
post	=1 if year>=2010; 0 otherwise	
DD	= Can*post (difference-in-difference estimate)	
parent	=1 if the firm has parent company; 0 otherwise	
ln(firm age)	ln(firm age)	
branch	= 1 if firm has at least two locations; 0 otherwise	
ROA	return to total assets = net profit/total assets	
sale growth	percentage change in sales	
CATA	current assets/total assets	
sub	=1 if government subsidy or grants >0; 0 otherwise	
entering	=1 if firm enters in this year and the following year; 0 otherwise	
ceasing	=1 if firm ceased in any years since September 2010; 0 otherwise	
territory	67 territorial authorities in New Zealand (a city or a district council)	
sector	Primary sector: agriculture, forestry & fishing (one-digit ANZSIC06 industry code A); Mining (code B) Manufacturing (code C) Construction (code E) Other services sector: all the remaining industries/codes	
firm size (four categories)	Micro=1 if number of full-time employee (FTE) <5; 0 otherwise Small=1 if number of FTE in the range [5; 20); 0 otherwise (excluding micro firms - adjusted from the MBIE classification) Medium=1 if number of FTE in the range [20; 50); 0 otherwise Large=1 if number of FTE >=50; 0 otherwise	Statistics NZ & MBIE (2017)
drought	using "potential-evapotranspiration-deficit" or PED, equals the percentage change in PED in 2012 or 2013 relative to value in 2011; equals 0 in all other years (accounts for the drought in 2012/2013 that might affect the treatment outcomes)	Ministry for Environment
gdp deflator	GDP deflator index (inflation), 2015==1	RBNZ

Table 2. Statistical description

Variable	Observation number	mean	variance	S.d.
investment I/K	1,882,614	0.136	0.448	0.669
ln(ta)	2,037,552	5.412	4.171	2.042
ln(afa)	1,520,160	2.796	5.213	2.283
ln(equity)	1,562,037	4.851	4.832	2.198
ln(debt)	1,896,327	1.452	6.161	2.482
debt ratio	1,807,677	0.190	0.801	0.895
sub	2,134,410	0.129	0.112	0.335
parent	2,134,410	0.034	0.033	0.182
branch	2,134,410	0.022	0.022	0.149
age	2,134,410	12.186	104.268	10.211
entering	2,134,410	0.056	0.052	0.230
ceasing	2,134,410	0.394	0.238	0.488
micro	2,134,410	0.798	0.160	0.401
small	2,134,410	0.154	0.130	0.361
medium	2,134,410	0.023	0.022	0.151
large	2,134,410	0.023	0.022	0.150
ROA	2,134,410	0.983	6.714	2.591
sale growth	2,134,410	1.597	11.075	3.327
CATA	2,134,410	0.430	0.117	0.343
Can	2,134,410	0.166	0.138	0.372
drought	2,134,410	0.188	0.420	0.648

Table 3. Impact of the Canterbury earthquakes on firm investment ratio I/K

I/K	(1)	(2)	(3)	(4)	(5)	(6)
DD	0.028***	0.021***	0.021***	0.022***		
	(0.004)	(0.004)	(0.004)	(0.003)		
DD*2010					0.014*	0.016**
					(0.006)	(0.006)
DD*2011					0.028***	0.029***
					(0.005)	(0.005)
DD*2012					0.039***	0.036***
					(0.006)	(0.006)
DD*2013					0.036***	0.030***
					(0.006)	(0.006)
DD*2014					0.041***	0.033***
					(0.006)	(0.006)
DD*2015					0.025***	0.017**
					(0.006)	(0.006)
DD*2016					0.022***	0.01~
					(0.006)	(0.006)
DD*2017					0.022***	0.011*
					(0.005)	(0.005)
DD*2018					0.033***	0.012*
					(0.005)	(0.005)
parent		-0.014	-0.014	-0.008		-0.009
		(0.01)	(0.01)	(0.009)		(0.009)
branch		0.006	0.006	-0.007		-0.004
		(0.005)	(0.005)	(0.005)		(0.005)
ln(age)		-0.473***	-0.473***	-0.116***		-0.117***
		(0.002)	(0.002)	(0.003)		(0.003)
entering				0.746***		0.743***
				(0.004)		(0.004)
_cons	0.366***	0.896***	0.835***	0.377***	0.367***	0.380***
	(0.01)	(0.021)	(0.004)	(0.024)	(0.01)	(0.024)
R-squared	0.017	0.064	0.064	0.092	0.017	0.091
obs	1,882,614	1,882,614	1,882,614	1,882,614	1,882,614	1,882,614
Firm number	301,527	301,527	301,527	301,527	301,527	301,527
year FEs	Y	Y	Y	Y	Y	Y
firm FEs	Y	Y	Y	Y	Y	Y
territory FEs	Y	Y	N	N	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 4. Impact of the Canterbury earthquakes on firm investment leveraged by industry

I/K	Primary			Manufacturing		Construction		Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DD	0.016**	0.014**		0.045***		0.034**		0.027***	
	(0.005)	(0.005)		(0.012)		(0.012)		(0.006)	
DD*2010			0.031**		0.049**		-0.019		0.017~
			(0.010)		(0.017)		(0.020)		(0.009)
DD*2011			0.022**		0.067***		0.062***		0.025**
			(0.008)		(0.016)		(0.017)		(0.008)
DD*2012			0.011		0.057**		0.130***		0.029**
			(0.010)		(0.020)		(0.020)		(0.009)
DD*2013			0		0.067***		0.109***		0.027**
			(0.010)		(0.017)		(0.019)		(0.009)
DD*2014			0.014		0.063***		0.060**		0.041***
			(0.010)		(0.018)		(0.020)		(0.009)
DD*2015			0.008		0.025		0.024		0.027**
			(0.010)		(0.018)		(0.020)		(0.009)
DD*2016			0.011		0.016		-0.028		0.026**
			(0.010)		(0.019)		(0.018)		(0.009)
DD*2017			0.012		0.026		-0.017		0.026**
			(0.008)		(0.017)		(0.016)		(0.008)
DD*2018			0.008		0.012		-0.021		0.032***
			(0.008)		(0.017)		(0.016)		(0.008)
parent	-0.011	-0.011	-0.011	-0.009	-0.01	-0.054	-0.053	-0.002	-0.003
	(0.021)	(0.021)	(0.021)	(0.020)	(0.020)	(0.054)	(0.054)	(0.012)	(0.012)
branch	0.001	0.001	0.001	-0.016	-0.011	-0.033	-0.018	-0.015*	-0.015*
	(0.009)	(0.009)	(0.009)	(0.012)	(0.013)	(0.033)	(0.033)	(0.006)	(0.007)
ln(firm age)	-0.121***	-0.121***	-0.121***	-0.095***	-0.097***	-0.090***	-0.089***	-0.114***	-0.114***
	(0.005)	(0.005)	(0.005)	(0.009)	(0.009)	(0.008)	(0.008)	(0.004)	(0.004)
entering	0.748***	0.748***	0.748***	0.726***	0.725***	0.751***	0.750***	0.752***	0.752***
	(0.007)	(0.007)	-0.007	(0.013)	(0.013)	(0.010)	(0.010)	(0.005)	(0.005)
drought		-0.007***	-0.008***						
		(0.002)	(0.002)						
_cons	0.299***	0.300***	0.299***	0.412***	0.415***	0.384***	0.382***	0.381***	0.381***
	(0.039)	(0.039)	(0.039)	(0.033)	(0.033)	(0.068)	(0.069)	(0.033)	(0.033)
R-squared	0.081	0.081	0.081	0.088	0.088	0.101	0.102	0.098	0.098
obs	562,407	562,407	562,407	131,514	131,514	225,321	225,321	955,368	955,368
Firm number	61,905	61,905	61,905	21,936	21,936	46,287	46,287	109,494	171,399
year FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 5. Impact of the Canterbury earthquakes on firm investment by firm size

I/K	All sectors		Primary	Manufacturing	Construction	Other services
	(1)	(2)	(3)	(4)	(5)	(6)
DD	0.093***	0.092***	0.007	0.134***	0.142***	0.132***
	(0.009)	(0.009)	(0.074)	(0.017)	(0.039)	(0.012)
DD*micro	-0.076***	-0.076***	0.011	-0.118***	-0.116**	-0.125***
	(0.010)	(0.010)	(0.074)	(0.022)	(0.040)	(0.013)
DD*small	-0.082***	-0.082***	-0.022	-0.112***	-0.045	-0.108***
	(0.013)	(0.013)	(0.075)	(0.027)	(0.059)	(0.019)
DD*medium	-0.023	-0.023	0.022	-0.052	-0.062	-0.027
	(0.020)	(0.020)	(0.089)	(0.033)	(0.078)	(0.026)
parent	-0.009	-0.009	-0.011	-0.01	-0.055	-0.004
	(0.009)	(0.009)	(0.021)	(0.020)	(0.054)	(0.012)
branch	-0.001	-0.001	0.001	0.004	-0.018	-0.002
	(0.005)	(0.005)	(0.009)	(0.013)	(0.034)	(0.007)
ln(firm age)	-0.115***	-0.115***	-0.121***	-0.092***	-0.089***	-0.113***
	(0.003)	(0.003)	(0.005)	(0.009)	(0.008)	(0.004)
entering	0.746***	0.746***	0.748***	0.728***	0.752***	0.753***
	(0.004)	(0.004)	(0.007)	(0.013)	(0.010)	(0.005)
drought		-0.004***	-0.007***			
		(0.001)	(0.002)			
_cons	0.376***	0.377***	0.299***	0.409***	0.383***	0.378***
	(0.024)	(0.024)	(0.039)	(0.033)	(0.068)	(0.033)
R-squared	0.092	0.092	0.081	0.088	0.101	0.098
obs	1,882,614	1,882,614	562,407	131,514	225,321	955,368
Firm number	301,527	301,527	61,905	21,936	46,287	171,399
FEs	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 6. Impact of the Canterbury earthquakes on firm total assets

	All sectors		Primary		Manufacturing		Construction		Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
DD	0.130***		0.113***		0.110***		0.219***		0.128***	
	(0.009)		(0.013)		(0.030)		(0.028)		(0.015)	
DD*2010		0.057***		0.088***		0.039		-0.005		0.070***
		(0.010)		(0.015)		(0.029)		(0.030)		(0.015)
DD*2011		0.077***		0.084***		0.036		0.071*		0.089***
		(0.010)		(0.016)		(0.034)		(0.033)		(0.016)
DD*2012		0.136***		0.110***		0.129***		0.298***		0.128***
		(0.011)		(0.016)		(0.033)		(0.035)		(0.017)
DD*2013		0.161***		0.135***		0.149***		0.360***		0.149***
		(0.011)		(0.016)		(0.035)		(0.036)		(0.017)
DD*2014		0.196***		0.151***		0.203***		0.441***		0.178***
		(0.012)		(0.018)		(0.037)		(0.038)		(0.018)
DD*2015		0.174***		0.097***		0.159***		0.396***		0.175***
		(0.012)		(0.019)		(0.039)		(0.039)		(0.019)
DD*2016		0.171***		0.131***		0.155***		0.287***		0.174***
		(0.012)		(0.019)		(0.040)		(0.040)		(0.019)
DD*2017		0.138***		0.135***		0.117**		0.215***		0.135***
		(0.012)		(0.019)		(0.039)		(0.037)		(0.019)
DD*2018		0.112***		0.109***		0.086*		0.129***		0.122***
		(0.012)		(0.020)		(0.040)		(0.037)		(0.019)
parent	0.276***	0.276***	0.005	0.004	0.363***	0.361***	0.327**	0.325**	0.313***	0.313***
	(0.023)	(0.023)	(0.043)	(0.043)	(0.060)	(0.060)	(0.112)	(0.112)	(0.030)	(0.030)
branch	0.122***	0.128***	0.132***	0.132***	0.025	0.039	0.009	0.046	0.098***	0.106***
	(0.009)	(0.009)	(0.015)	(0.015)	(0.026)	(0.027)	(0.062)	(0.062)	(0.012)	(0.012)
ln(age)	0.132***	0.133***	0.233***	0.233***	0.162***	0.163***	0.246***	0.248***	0.077***	0.078***
	(0.005)	(0.005)	(0.009)	(0.009)	(0.020)	(0.020)	(0.016)	(0.016)	(0.008)	(0.008)
entering	0.042***	0.042***	0.094***	0.094***	0.048*	0.049*	0.082***	0.083***	0.025**	0.026**
	(0.006)	(0.006)	(0.010)	(0.010)	(0.021)	(0.021)	(0.017)	(0.017)	(0.008)	(0.008)
_cons	5.391***	5.384***	6.297***	6.297***	5.425***	5.418***	4.156***	4.151***	5.154***	5.154***
	(0.036)	(0.036)	(0.050)	(0.050)	(0.055)	(0.055)	(0.076)	(0.076)	(0.042)	(0.042)
R-squared	0.008	0.008	0.015	0.015	0.017	0.018	0.032	0.034	0.013	0.013
obs	2,028,441	2,028,441	591,639	591,639	140,133	140,133	242,187	242,187	1,054,485	1,054,485
Firm number	301,527	301,527	61,905	61,905	21,936	21,936	46,287	46,287	171,399	171,399
FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 7. Impact of the Canterbury earthquakes on addition to fixed assets

	All sectors		Primary		Manufacturing		Construction		Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
DD	0.184***		0.185***		0.164***		0.356***		0.170***	
	(0.013)		(0.021)		(0.047)		(0.045)		(0.021)	
DD*2010		0.194***		0.290***		0.151*		0.138*		0.167***
		(0.020)		(0.033)		(0.065)		(0.063)		(0.028)
DD*2011		0.127***		0.152***		0.063		0.213**		0.114***
		(0.020)		(0.032)		(0.070)		(0.068)		(0.030)
DD*2012		0.247***		0.174***		0.308***		0.551***		0.236***
		(0.019)		(0.031)		(0.066)		(0.065)		(0.029)
DD*2013		0.266***		0.255***		0.214**		0.699***		0.217***
		(0.020)		(0.034)		(0.067)		(0.068)		(0.029)
DD*2014		0.308***		0.267***		0.342***		0.682***		0.269***
		(0.020)		(0.035)		(0.066)		(0.067)		(0.030)
DD*2015		0.174***		0.149***		0.137*		0.373***		0.170***
		(0.019)		(0.033)		(0.062)		(0.062)		(0.028)
DD*2016		0.172***		0.191***		0.094		0.200**		0.179***
		(0.019)		(0.034)		(0.064)		(0.062)		(0.028)
DD*2017		0.084***		0.089**		0.09		0.151**		0.098***
		(0.018)		(0.032)		(0.063)		(0.056)		(0.027)
DD*2018		0.042*		0.022		0.037		0.113		0.063*
		(0.019)		(0.034)		(0.063)		(0.059)		(0.028)
parent	0.077**	0.077**	-0.028	-0.027	0.246***	0.244***	0.095	0.095	0.074*	0.075*
	(0.028)	(0.028)	(0.076)	(0.076)	(0.065)	(0.065)	(0.130)	(0.129)	(0.035)	(0.035)
branch	0.164***	0.177***	0.229***	0.230***	0.064	0.084*	0.002	0.062	0.100***	0.115***
	(0.015)	(0.015)	(0.030)	(0.030)	(0.040)	(0.042)	(0.081)	(0.081)	(0.019)	(0.019)
ln(age)	-0.145***	-0.146***	-0.115***	-0.114***	-0.065*	-0.068*	-0.092***	-0.090***	-0.172***	-0.174***
	(0.008)	(0.008)	(0.015)	(0.015)	(0.031)	(0.031)	(0.026)	(0.026)	(0.012)	(0.012)
entering	1.285***	1.284***	1.653***	1.654***	1.280***	1.278***	1.042***	1.041***	1.188***	1.186***
	(0.011)	(0.011)	(0.021)	(0.021)	(0.040)	(0.040)	(0.030)	(0.030)	(0.014)	(0.014)
_cons	3.211***	3.211***	4.927***	4.924***	2.938***	2.944***	2.318***	2.313***	3.205***	3.206***
	(0.074)	(0.073)	(0.115)	(0.115)	(0.130)	(0.130)	(0.201)	(0.203)	(0.084)	(0.084)
R-squared	0.059	0.059	0.059	0.059	0.056	0.056	0.062	0.063	0.063	0.063
obs	1,513,866	1,513,866	484,974	484,974	106,614	106,614	170,283	170,283	751,995	751,995
Firm number	295,650	295,650	61,506	61,506	21,936	21,936	44,961	44,961	161,247	161,247
FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 8. Possible channels for Canterbury firms to increase investment

Dependent variable	ln(equity)		ln(total debt)		debt-to-asset ratio			investment I/K	
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)
DD	0.178***		0.040*		-0.036***		DD	0.018***	0.019***
	(0.011)		(0.017)		(0.006)			(0.004)	(0.004)
							DD*sub	0.019***	
								(0.004)	
DD*2010		0.065***		0.024		-0.019*	DD*sub*2010		0.046
		(0.013)		(0.016)		(0.009)			(0.031)
DD*2011		0.096***		-0.012		-0.060***	DD*sub*2011		0.008
		(0.013)		(0.038)		(0.017)			(0.005)
DD*2012		0.143***		0.005		-0.063***	DD*sub*2012		0.014*
		(0.014)		(0.040)		(0.015)			(0.006)
DD*2013		0.242***		0.044*		-0.038***	DD*sub*2013		0.086**
		(0.015)		(0.020)		(0.009)			(0.028)
DD*2014		0.265***		0.043*		-0.041***	DD*sub*2014		0.113***
		(0.015)		(0.021)		(0.010)			(0.026)
DD*2015		0.236***		0.053*		-0.046***	DD*sub*2015		0.080***
		(0.015)		(0.022)		(0.009)			(0.023)
DD*2016		0.248***		0.059**		-0.051***	DD*sub*2016		0.129***
		(0.015)		(0.022)		(0.008)			(0.030)
DD*2017		0.216***		0.054*		-0.028**	DD*sub*2017		0.158***
		(0.015)		(0.023)		(0.009)			(0.030)
DD*2018		0.193***		0.053*		-0.034***	DD*sub*2018		0.173***
		(0.016)		(0.023)		(0.009)			(0.030)
							sub	0.084***	0.075***
								(0.004)	(0.004)
R-squared	0.013	0.013	0.006	0.006	0.019	0.019		0.092	0.092
obs	1,556,931		566,688		1,798,608			1,882,614	
Firm number	299,265		170,133		301,527			301,527	
FEs	Y	Y	Y	Y	Y	Y		Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns control for parent, branch, firm age, and entering, though these coefficients are not shown here. Unreported fixed effects include year fixed effects, firm fixed effects, and territory fixed effects. Subsidy “sub” is a dummy variable taking the value of 1 if firms receive subsidy in the year, 0 otherwise.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 9. Robustness checks - Using only Waikato as the control group

I/K	All sectors	Primary	Agriculture	Manufacturing	Construction	Other services
	(1)	(2)	(3)	(4)	(5)	(6)
DD	0.020***	0.038***	0.038***	0.039*	0.033*	0.031***
	(0.005)	(0.007)	(0.007)	(0.019)	(0.016)	(0.009)
parent	-0.004	0.018	0.028	0.021	-0.107	-0.01
	(0.014)	(0.023)	(0.025)	(0.024)	(0.097)	(0.020)
branch	-0.013*	-0.016	-0.007	-0.023~	-0.053	-0.017~
	(0.007)	(0.015)	(0.016)	(0.014)	(0.037)	(0.009)
ln(firm age)	-0.121***	-0.127***	-0.126***	-0.116***	-0.105***	-0.120***
	(0.005)	(0.008)	(0.008)	(0.016)	(0.015)	(0.007)
entering	0.739***	0.737***	0.746***	0.674***	0.738***	0.749***
	(0.007)	(0.011)	(0.012)	(0.024)	(0.020)	(0.010)
drought		0.017~	0.013			
		(0.010)	(0.010)			
_cons	0.261*	0.288***	0.266***	0.511***	0.243**	0.459***
	(0.102)	(0.031)	(0.033)	(0.041)	(0.088)	(0.096)
R-squared	0.092	0.086	0.087	0.084	0.112	0.095
obs	537,033	197,901	181,956	36,309	60,774	242,046
Firm number	79,932	22,338	19,470	5,799	12,486	43,911
FEs	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level.
All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects. The samples in all regressions only include Canterbury and Waikato firms.
DD is the difference-in-difference estimate for the Canterbury region while Waikato is the control.

Table 10. Placebo test using Waikato as the treatment group

	All New Zealand firms						All Zealand firms excluding Canterbury					
	All sectors	Primary	Agriculture	Manufacturing	Construction	Other services	All sectors	Primary	Agriculture	Manufacturing	Construction	Other services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DDw	-0.002	-0.026***	-0.027***	-0.006	-0.006	-0.011	0.003	-0.024***	-0.026***	0.005	0.001	-0.005
	(0.004)	(0.005)	(0.005)	(0.017)	(0.013)	(0.008)	(0.004)	(0.005)	(0.005)	(0.017)	(0.013)	(0.008)
parent	-0.008	-0.011	-0.001	-0.009	-0.053	-0.002	-0.008	-0.024	-0.013	-0.024	-0.031	0.002
	(0.009)	(0.021)	(0.023)	(0.020)	(0.054)	(0.012)	(0.012)	(0.027)	(0.030)	(0.027)	(0.059)	(0.015)
branch	-0.009	0.001	0.006	-0.023	-0.037	-0.018**	-0.007	0	0.004	0.016	0.024	-0.018*
	(0.005)	(0.009)	(0.009)	(0.012)	(0.033)	(0.006)	(0.006)	(0.010)	(0.011)	(0.021)	(0.052)	(0.009)
ln(firm age)	-0.116***	-0.121***	-0.120***	-0.097***	-0.089***	-0.115***	-0.115***	-0.116***	-0.115***	-0.088***	-0.087***	-0.115***
	(0.003)	(0.005)	(0.005)	(0.009)	(0.008)	(0.004)	(0.003)	(0.005)	(0.005)	(0.010)	(0.009)	(0.004)
entering	0.746***	0.748***	0.760***	0.725***	0.752***	0.752***	0.748***	0.754***	0.765***	0.739***	0.756***	0.752***
	(0.004)	(0.007)	(0.007)	(0.013)	(0.010)	(0.005)	(0.004)	(0.008)	(0.008)	(0.015)	(0.011)	(0.005)
drought		-0.008***	-0.009***					-0.008***	-0.009***			
		(0.002)	(0.002)					(0.002)	(0.002)			
_cons	0.377***	0.299***	0.265***	0.413***	0.384***	0.381***	0.325***	0.299***	0.263***	0.357***	0.354***	0.384***
	(0.024)	(0.039)	(0.039)	(0.033)	(0.068)	(0.033)	(0.028)	(0.043)	(0.043)	(0.039)	(0.061)	(0.020)
R-squared	0.092	0.081	0.082	0.088	0.101	0.098	0.093	0.081	0.081	0.09	0.1	0.1
obs	1,882,614	562,407	506,919	131,514	225,321	955,368	1,562,592	467,592	419,976	107,685	188,307	799,008
Firm number	301,527	61,905	53,535	21,936	46,287	171,399	254,208	51,375	44,418	18,207	38,541	143,565
FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level. All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects. DDw is the difference-in-difference estimate when Waikato is used as the treatment group.

Table 11. Impacts of the Canterbury earthquakes on firm investment, conditional on survival

I/K	All		Primary			Manufacturing		Construction		Other services	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
DD	0.045***	0.045***	0.026***	0.024***	0.026***	0.056***	0.056***	0.065***	0.065***	0.057***	0.057***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.012)	(0.012)	(0.014)	(0.014)	(0.007)	(0.007)
DD*ceasing	-0.080***		-0.047***	-0.048***		-0.038		-0.080***		-0.089***	
	(0.007)		(0.012)	(0.012)		(0.025)		(0.023)		(0.011)	
DD*ceasing*2010		-0.067***			0		-0.018		-0.145***		-0.073***
		(0.011)			(0.019)		(0.030)		(0.035)		(0.016)
DD*ceasing*2011		-0.050***			-0.008		0.008		-0.026		-0.069***
		(0.009)			(0.016)		(0.030)		(0.028)		(0.014)
DD*ceasing*2012		-0.066***			-0.050*		-0.05		0.039		-0.087***
		(0.012)			(0.023)		(0.042)		(0.036)		(0.018)
DD*ceasing*2013		-0.077***			-0.075**		0.03		-0.025		-0.097***
		(0.012)			(0.024)		(0.035)		(0.036)		(0.018)
DD*ceasing*2014		-0.093***			-0.103**		-0.058		-0.093*		-0.083***
		(0.013)			(0.033)		(0.046)		(0.036)		(0.018)
DD*ceasing*2015		-0.122***			-0.101***		-0.129*		-0.158***		-0.110***
		(0.014)			(0.030)		(0.054)		(0.045)		(0.019)
DD*ceasing*2016		-0.142***			-0.130**		-0.134**		-0.180***		-0.135***
		(0.016)			(0.043)		(0.049)		(0.036)		(0.022)
DD*ceasing*2017		-0.142***			-0.078*		-0.156*		-0.160***		-0.150***
		(0.016)			(0.036)		(0.062)		(0.035)		(0.022)
DD*ceasing*2018		-0.171***			-0.038		-0.170*		-0.198***		-0.187***
		(0.020)			(0.035)		(0.074)		(0.041)		(0.028)
drought				-0.007***	-0.007***						
				(0.002)	(0.002)						
_cons	0.375***	0.375***	0.300***	0.300***	0.300***	0.411***	0.410***	0.382***	0.382***	0.379***	0.379***
	(0.024)	(0.024)	(0.039)	(0.039)	(0.039)	(0.033)	(0.033)	(0.068)	(0.068)	(0.033)	(0.033)
R-squared	0.092	0.092	0.081	0.081	0.081	0.088	0.088	0.101	0.101	0.098	0.098
obs	1,882,614	1,882,614	562,407	562,407	562,407	131,514	131,514	225,321	225,321	955,368	955,368
Firm number	301,527	301,527	61,905	61,905	61,905	21,936	21,936	46,287	46,287	171,399	171,399
FEs	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level. All columns control for parent, branch, firm age, and entering, though these coefficients are not shown here. Unreported fixed effects include year fixed effects, firm fixed effects, and territory fixed effects.
Ceasing is a dummy variable including all firms that ceased after the first major quake in September 2010 until 2018.
DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

Table 12. Robustness checks - Drop all micro firms with average employment <=1

I/K	All sectors	Primary	Manufacturing	Construction	Other services
	(1)	(2)	(3)	(4)	(5)
DD	0.021***	0.003	0.057***	0.046**	0.033***
	(0.005)	(0.007)	(0.013)	(0.018)	(0.007)
parent	-0.004	-0.003	-0.006	-0.091	0.004
	(0.010)	(0.024)	(0.021)	(0.056)	(0.014)
branch	-0.002	0.011	-0.006	-0.027	-0.01
	(0.005)	(0.010)	(0.013)	(0.029)	(0.007)
ln(firm age)	-0.109***	-0.126***	-0.080***	-0.116***	-0.104***
	(0.003)	(0.006)	(0.011)	(0.013)	(0.005)
entering	0.722***	0.717***	0.708***	0.648***	0.739***
	(0.005)	(0.009)	(0.016)	(0.016)	(0.006)
drought		-0.007***			
		(0.002)			
_cons	0.425***	0.330***	0.419***	0.532***	0.375***
	(0.017)	(0.038)	(0.029)	(0.121)	(0.033)
R-squared	0.092	0.092	0.081	0.09	0.096
obs	1,035,861	267,531	91,569	94,110	582,651
Firm number	178,059	30,594	15,156	22,869	109,440
FEs	Y	Y	Y	Y	Y

~ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. Robust standard errors are in the parenthesis, clustered by firm level. All columns add unreported fixed effects including year fixed effects, firm fixed effects, and territory fixed effects. DD is the difference-in-difference estimate for the Canterbury region while the rest of New Zealand is the control.

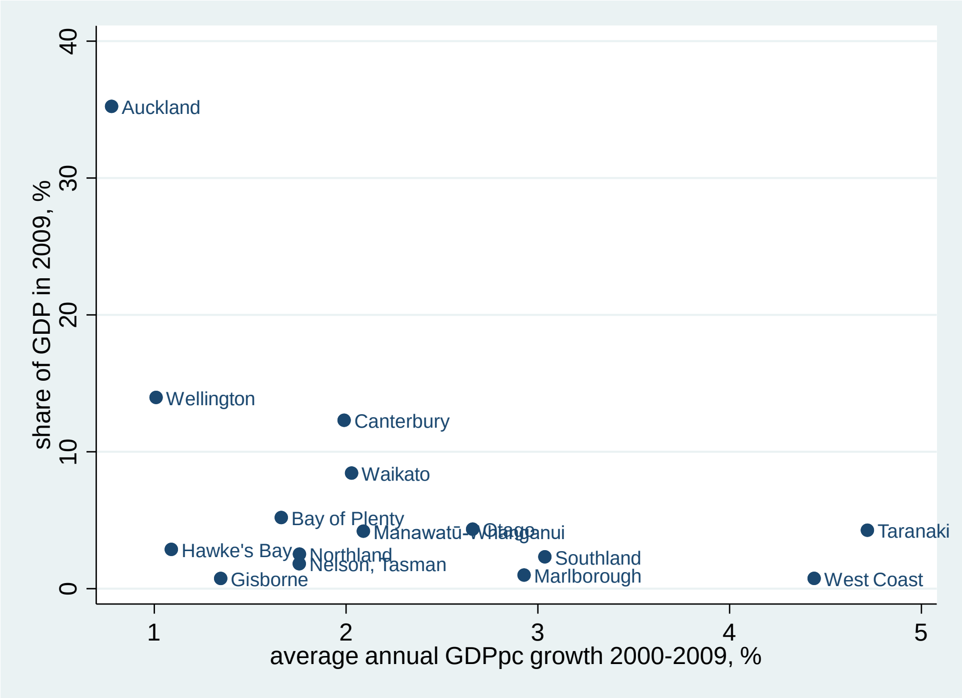

Figure 1. Regional GDP per capita and share of GDP before the Canterbury earthquakes

Source: Statistics New Zealand, and author's calculation.

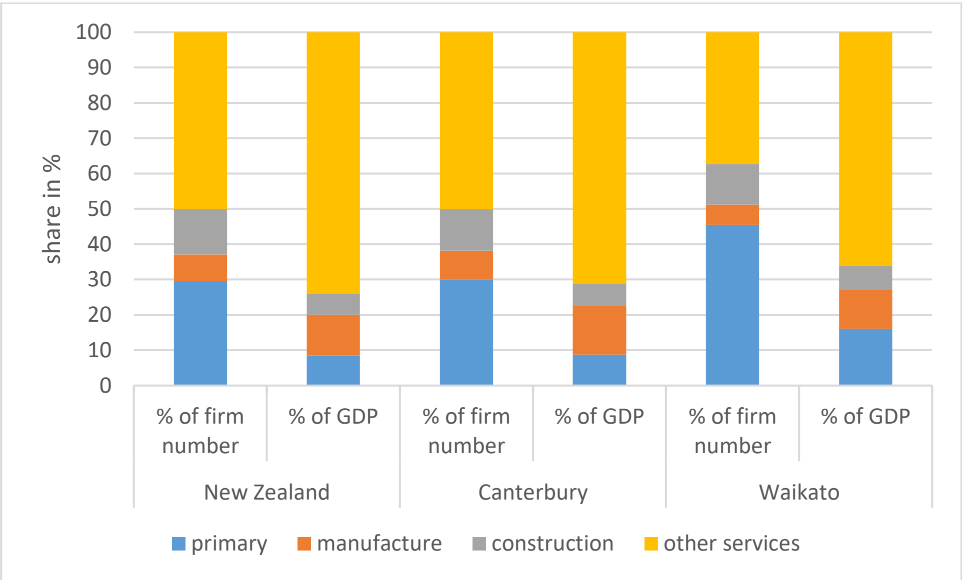

Figure 2. Sectoral economic contribution in New Zealand before the Canterbury earthquakes

Source: Statistics New Zealand, Annual Enterprise Surveys, and author's calculation. Note: averaged share over the period 2000-2009.

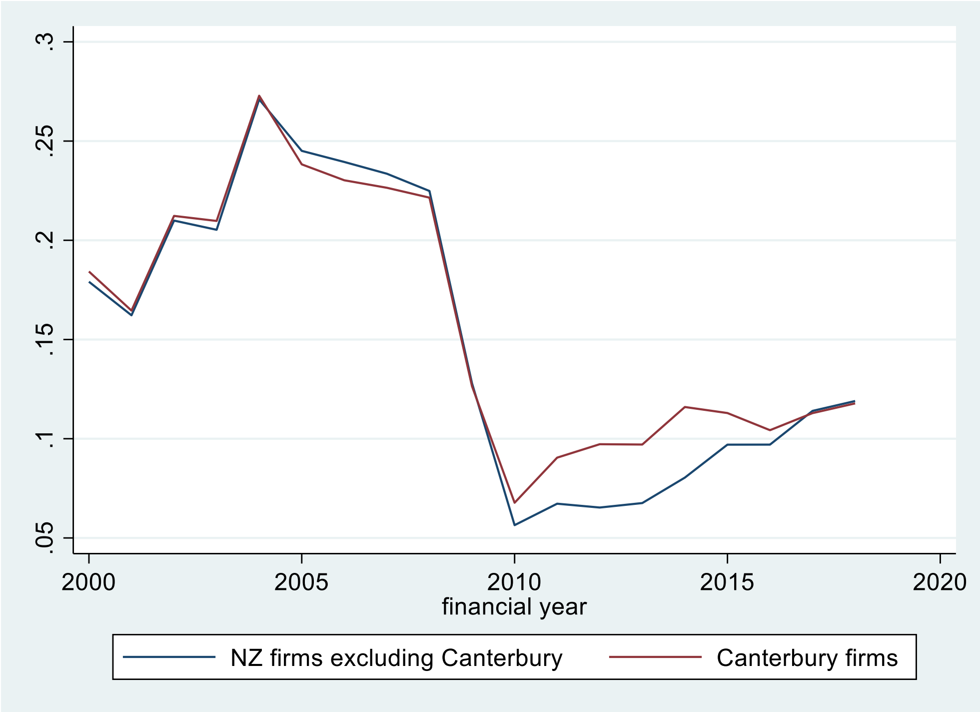

Figure 3. New Zealand firm investment ratio over the period 2000 - 2018

Source: Annual Enterprise Surveys from Statistics New Zealand, and author's calculation.

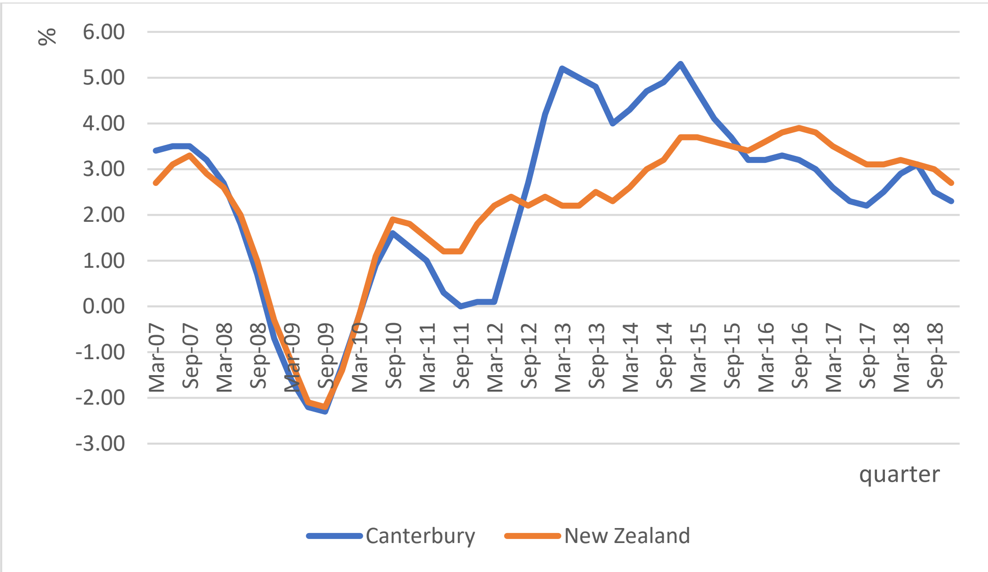

Figure 4. Economic growth in Canterbury and New Zealand 2007-2018

Source: Greater Christchurch Partnership, https://www.greaterchristchurch.org.nz/our-work/indicators/economic/gross-domestic-product, assessed on 20th May 2021

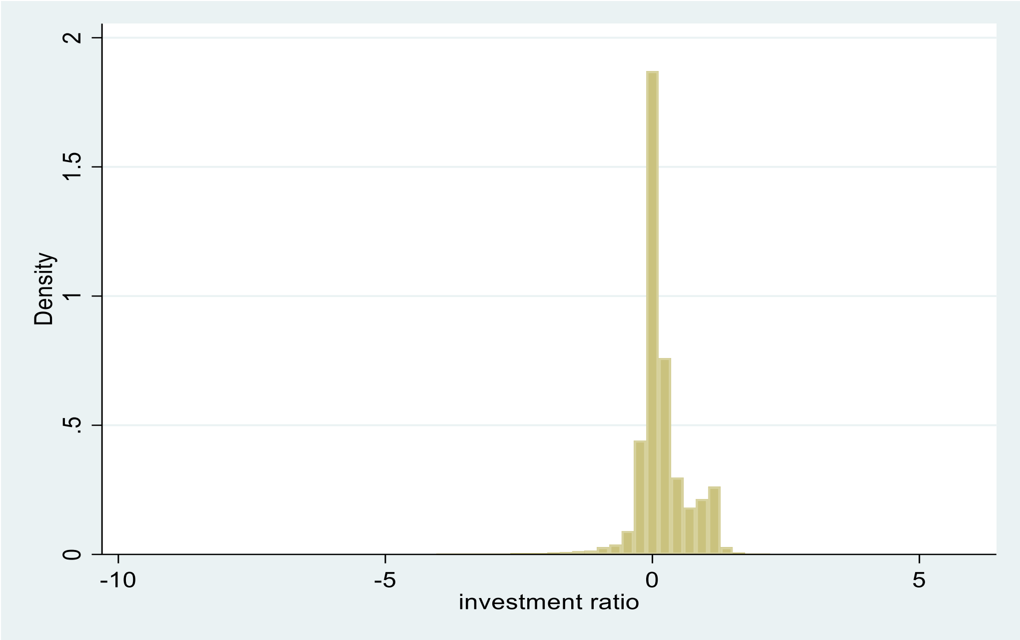

Figure 5. Historical distribution of New Zealand firm investment 2000 - 2018

Source: Annual Enterprise Surveys from Statistics New Zealand

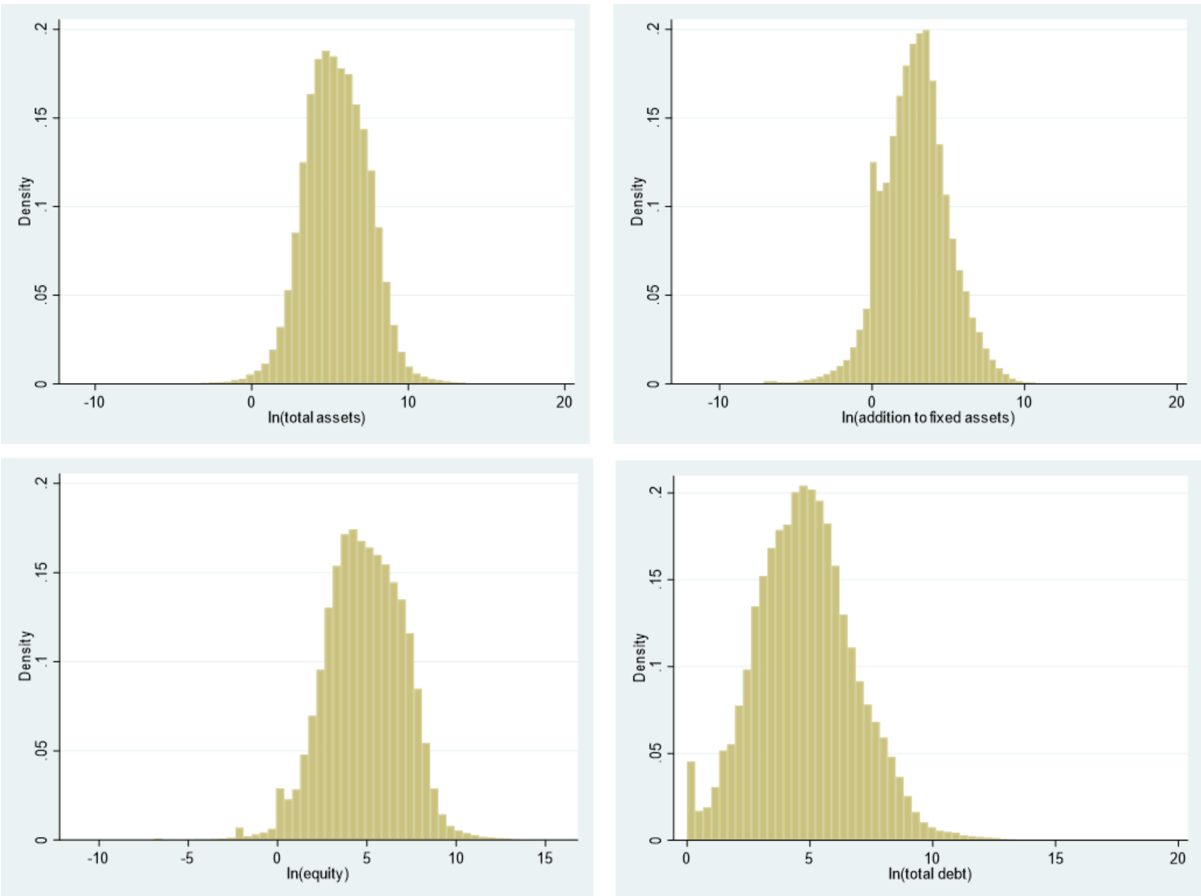

Figure 6. Historical distribution of NZ firms' capital stock, equity, and debt 2000 - 2018

Source: Annual Enterprise Surveys from Statistics New Zealand

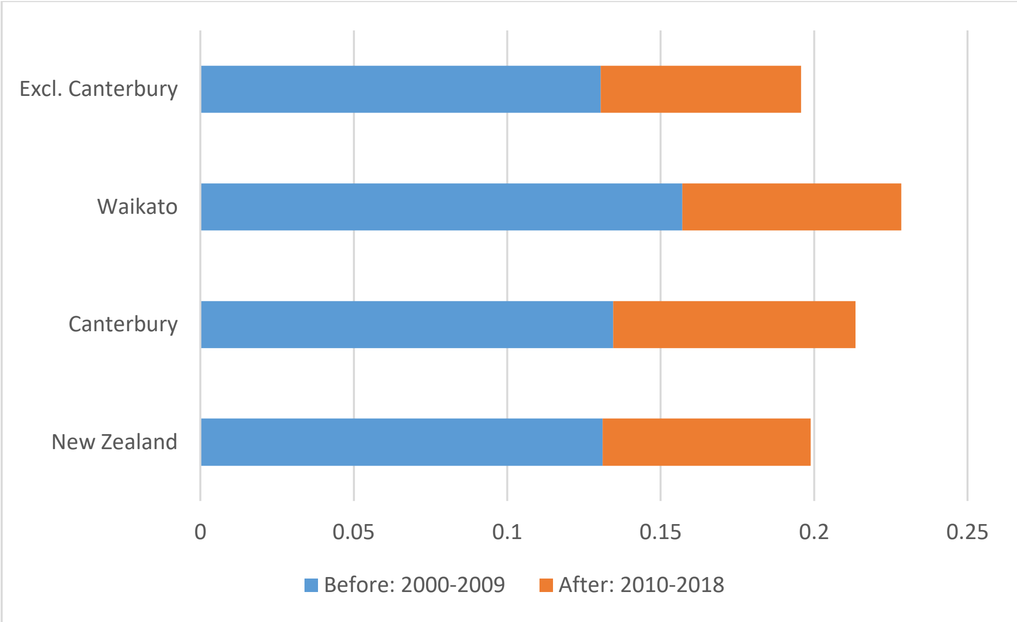

Figure 7. Investment ratio in agricultural sector before and after the Canterbury earthquakes

Source: Annual Enterprise Surveys from Statistics New Zealand, and author's calculation.

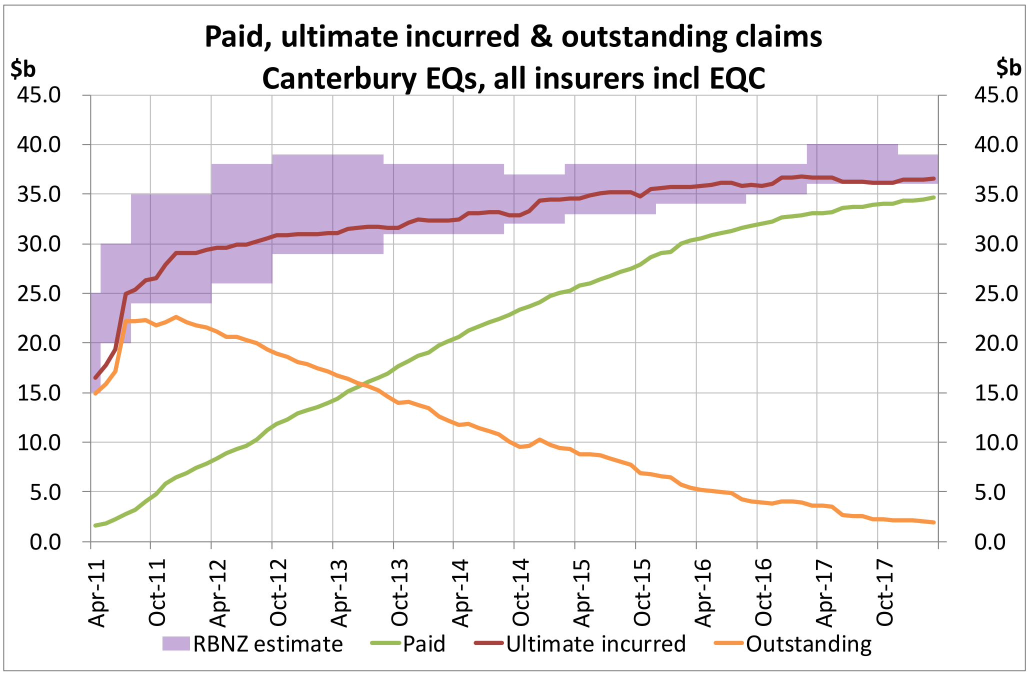

Figure 8. Insurance claims for the Canterbury earthquakes 2010/11 (until 31st March 2018)

Source: RBNZ (2018)

Appendix

Table 1A. Literature review about impacts of disasters on firm performance

Works	Research questions	Sample	Research Design	Findings
		(i) International experience		
Hosono et al. (2016)	If loan supply shocks (damage to banks caused by 1995 Kobe quake) affect firm investment	1,955 firms in Hyogo and Osaka prefectures over three years from 1995-1997	A natural experiment: - Uses a unique data set to identify firms and banks in the earthquake-affected areas - Compares investment ratio of firms *outside* the earthquake-affected areas but having a main bank *inside* the areas AND that of firms *outside* the areas and having a main bank *outside* the areas -Estimation: difference-in-difference (separately for 3 FY).	Damaged firms significantly increased their investment ratio *(gross investment/capital stock)* in FY1995 and two following years as they recovered from the damage. However, they did not examine the heterogeneity across sectors.
Basker and Miranda (2018)	study business survival and growth in the aftermath of a capital-destruction shock	- 10,000 firms in Mississippi, including over 1500 firms in four counties that had significant damage - 2004-2010	A natural experiment: - Treatment: damaged firms (classified by severe damage and mild damage) - Control: undamaged firms.	- Low survival rates for firms with physical damage, particularly for small firms and less-productive establishments. - Conditional on survival, larger and more-productive firms had an advantage rebuilding their operations quickly and hired more workers.
Leiter et al. (2009)	Impacts of floods on firms' capital accumulation, employment, and productivity	Firms in the selected European countries	-Estimation: difference-in-difference approach	In the short run, firms in regions hit by a flood show higher growth of total assets than firms unaffected.

(ii) New Zealand's experience				
Fabling et al. (2014)	Analyse the differential effects of these quakes across firms, particularly survival opportunity, profitability, and other outcomes (sales & purchase, employment)	- Firms in Greater Christchurch (treatment), Auckland and Hamilton (Control) - 25 months after the first quake	Two difference-in-difference approaches: (1) The first: - Treatment: affected firms in Greater Christchurch - Control: firms in Auckland and Hamilton. (2) The second: - Treatment: directly affected firms in Greater Christchurch - Control: unaffected firms in Greater Christchurch (or affected indirectly)	Conditional on survival, average profitability returned to pre-quake levels relatively quickly, albeit subject to reduced inputs.
Fabling et al. (2016)	- examine the consequential effect on jobs and accumulated earnings for workers in Canterbury. - examine concurrent decisions about employment location.	- Total 144,300 jobs in private-for-profit firms. - Workers in Christchurch, Auckland, and Hamilton - 43 months after the first quake	Two difference-in-difference approaches: (1) The first approach compares changes in labour market outcomes of affected workers in Greater Christchurch to "similar" unaffected workers in Auckland and Hamilton City. (2) The second approach compares subgroups of Christchurch workers, distinguished by worker characteristics, pre-quake job location, and/or whether the employer received the Earthquake Support Subsidy.	
Inland Revenue (2015)	Assessing the medium/longer term impact on Canterbury's SME economy	- 2003-3015 - Canterbury's SMEs	Statistical description and analysis	Canterbury debt as % of turnover increased relative to NZ firm in 2014 and 2015.