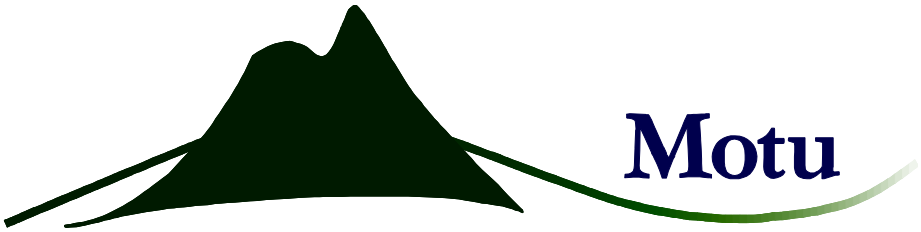

Natural selection: Firm performance following the Canterbury earthquakes

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Disclaimer

The results in this paper are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI) managed by Statistics New Zealand. The opinions, findings, recommendations and conclusions expressed in this paper are those of the authors not Statistics NZ, MBIE, Motu, GNS Science or the University of Auckland.

Access to the anonymised data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business or organisation and the results in this paper have been confidentialised to protect these groups from identification.

Careful consideration has been given to the privacy, security and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the privacy impact assessment for the IDI available from www.stats.govt.nz.

The results are based in part on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit-record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

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Abstract
The Canterbury earthquakes in September 2010 and February 2011 caused major upheaval to the people of the region. The second quake killed 185 people, forced many from their homes, and closed Christchurch's central business district. This paper examines the consequential effects on business in the region, paying particular attention to heterogeneity in firm-level outcomes. Consistent with aggregate statistics, we quantify substantial variation in firm outcomes by industry and by location. In addition, we show that firms' prior financial viability heavily influenced their chance of survival. Conditional on continuing to operate, average profitability returned to pre-quake levels relatively quickly, albeit subject to reduced inputs. Taken together, these effects support economic models where firm exit is driven by selection on profitability.

JEL codes
D22; L11; Q54

Keywords
Natural disasters; business survival; response to shocks; difference-in-difference

1 Motivation

The Canterbury earthquake sequence was the most damaging natural hazard event in New Zealand's written history. The February 2011 quake killed 185 people, forced many from their homes, and closed Christchurch's CBD. Both the September 2010 and February 2011 earthquakes caused major damage to land, property and infrastructure. The scope of the disaster presents an important opportunity for learning about post-event market responses and community resilience.

The focus of this paper is on the effect of the quakes on business in the region. Recent analysis has begun to uncover the aggregate impact of the earthquakes on Christchurch businesses and workers. The number of business locations dropped substantially in the year following the February event – down 2.5 percent overall, but down 34.6 percent in the CBD (Statistics New Zealand 2012). Census estimates show a declining population in Christchurch City dropping a total of 4 percent in the two years to June 2012 (Statistics New Zealand 2014a). Consistent with the declining workforce, firms have reported difficulty hiring workers in Christchurch, with employers attributing this mainly to people leaving the area and to difficulty in attracting new staff to Christchurch (MBIE 2012).

The Treasury (2013) estimates that total investment associated with the rebuild will be around $40 billion.[1] As a result, the industry composition of the region's workforce has changed markedly, with a large (59 percent) jump in the number of workers employed in the construction industry, making it the largest employing sector in Greater Christchurch (Statistics New Zealand 2014a).[2] Conversely, other industries, such as retail and hospitality, experienced an initial decline in sales, but have since recovered and are currently growing at above the national average rate (Statistics New Zealand 2014b).

While these regional aggregates demonstrate the scale of change, they cannot paint a detailed picture of the economic costs experienced and the adjustments that have taken place after the disaster. To fill this gap in understanding, we add to a small but growing set of microeconomic analyses

[1] This investment is spread across residential property ($18b), commercial property ($9b) and infrastructure and social assets ($11b).

[2] Greater Christchurch is taken here to include the Territorial Authorities of Christchurch City, Selwyn District and Waimakariri District. Greater Christchurch is treated as the affected area in this paper, and we use this term interchangeably with Christchurch for simplicity.

of natural disasters to investigate the differential effects across firms.[3]

The paper is most similar to Basker and Miranda (2014) in both intent and methodology. Both papers use a difference-in-difference estimation approach to understand hetogeneity in survival and growth outcomes based on prior firm performance. Basker and Miranda (2014) have the advantage of being able to consider the dynamics of recovery over a longer time frame. We have the advantage of access to financial data, allowing direct measurement of prior profitability, rather than relying on proxy measures (firm size and age) as in Basker and Miranda (2014).

In the New Zealand context, this paper has similarities to the work of Inland Revenue (Inland Revenue 2014), particularly the use of tax data to measure changes in sales post-quake. Where Inland Revenue present statistics on survival and sales levels using simple counterfactuals based on historical Canterbury or national averages, we match within detailed firm cells, track a larger number of outcome variables, and examine heterogeneity of outcomes on more dimensions, enabled by the linking of the tax data to firm characteristics held by Statistics New Zealand.

Consistent with aggregate statistics, we quantify substantial variation in firm outcomes by industry and by location. We show that firms' prior financial viability materially influenced their chance of survival. Conditional on continuing to operate, average profitability returned to pre-quake levels relatively quickly, albeit subject to reduced inputs. Taken together, these effects support economic models where firm exit is at least partly driven by selection on profitability.

Section 2 outlines the empirical method, while section 3 describes the data that we use. Results are discussed in section 4 before we summarise our findings in section 5.

2 Hypotheses and estimation approach

The empirical strategy triangulates two difference-in-difference (DID) approaches. The first DID approach compares outcomes (changes in performance pre- and post-quakes) of affected firms in Greater Christchurch to "similar" unaffected firms in Auckland and Hamilton City (the "control"

[3]This literature includes studies of Hurricane Katrina (eg, Basker and Miranda 2014); the Kobe and Tohoku earthquakes (eg, Cole et al. 2013; Uchida et al. 2013 respectively); and major flooding in European regions (eg, Leiter et al. 2009).

group). The second approach compares subgroups of Christchurch firms. The first comparison provides a counterfactual for what might have happened to affected firms in the absence of the earthquakes. The second DID approach demonstrates the heterogeneity of outcomes between firms directly affected by the earthquakes and those affected indirectly through, say, reduced demand or supply chain interruption. It also explores whether firm characteristics, such as ownership type or firm size, exacerbate or mitigate effects.

The potential for marked heterogeneity in outcomes is a key motivating factor for this paper, for two reasons. Firstly, to accurately estimate the potential impact of future disasters, we need to understand the heterogeneity in outcomes across businesses. If firm-level outcomes vary by activity and location, as suggested by macroeconomic statistics, then insights for other regions must account for variations in industry structure and the distribution of firms inside and outside natural hazard risk zones. For this reason, we consider the intensity of the shock as an important dimension of the analysis. Whereas firms in less directly affected physical locations may experience disruption to supply chains, reduced (or increased) demand, and increased (or reduced) staff turnover, firms in severely affected areas may also suffer from forced suspension of business (eg, because they were located in the CBD, which was cordoned off following the February 2011 earthquake).

Secondly, heterogeneity across firms may give general insights into firm responses to shocks *beyond* the sphere of natural disasters. In particular, we are interested in uncovering determinants of firms' ability to be resilient to shocks. Among other things, resilience could be manifested through geographic diversity (multiple locations), mobility of factors of production, or financial performance. In particular, firm exit is a common phenomenon in the New Zealand economy (48,000 enterprises ceased operation in the year to February 2012, Statistics New Zealand 2012) and is correlated with relatively low (labour) productivity (Law and McLellan 2005).[4] We directly test whether prior profitability affects the exit decision, exploiting the fact that the quakes were an exogenous, unanticipated shock to performance.

Since the composition of firms within Greater Christchurch may differ from the control regions (Auckland and Hamilton), we reweight control observations so that they reflect the distribution of Christchurch firms. Matching is exact within industry, firm size, and prior employment growth cells. We

[4]Substantial firm exit rates are observed in other economies also (Bartelsman et al. 2005), with New Zealand entry/exit rates, and their contribution to aggregate employment growth, within the range observed across the OECD (Criscuolo et al. 2014).

also control directly for pre-existing firm characteristics, particularly at a detailed industry level, to eliminate the possible confounding effect of sector-specific macroeconomic shocks.[5] The following section describes the outcome variables, controls and matching cells.

3 Data

Aside from information about location-specific earthquake intensity, all data are obtained from New Zealand's Longitudinal Business Database (LBD) and Linked Employer-Employee Data (LEED), both maintained by Statistics New Zealand as part of the Integrated Data Infrastructure.[6]

Measured outcomes are restricted to those obtainable from timely full-coverage tax-based data on employment and wages (from Pay-As-You-Earn returns) and sales and purchases (from Goods and Services Tax data). This data is linked within the LBD to the Longitudinal Business Frame, which identifies business locations, industry, group structure, ownership type and sector. Firms are tracked over time using Fabling's (2011) enhanced longitudinal identifiers.

Outcomes are measured at the aggregate firm level, rather than the plant level because the former is the filing unit.[7] Denoting firm-level employment, total wage bill, sales and purchases as L, W, Y and M respectively, and using return on sales as a measure of profitability ($\pi = (Y-M-W)/Y$),[8] we track changes in the following outcomes:[9,10]

1. Employment status, $\Delta\delta(L > 0)$

[5] Average effects were also estimated excluding additional controls. For all outcomes these results were similar to results including controls.

[6] We use the December 2013 instance of IDI Clean, together with the current (2014) LBD. Fabling (2009) describes the LBD in more detail.

[7] We explicitly test whether firm-level effects are weaker for multi-location firms.

[8] This variable is not logged so as to retain the significant proportion of firms that have negative profitability at any given point in time. We normalise by sales, rather than capital, since it may be hard to value the latter after the quakes (and would require additional data linking, which would restict the population of interest). π is naturally bounded above by one, and we impose a lower bound at minus one to truncate a small number of extreme values.

[9] $\delta(.)$ is an indicator function equal to one if the argument holds, and zero otherwise.

[10] We also examined changes in average wages (ie, $\Delta ln(W/L)$). These results show a mildly elevated wage growth trend for surviving Greater Christchurch firms, and are not reported for brevity.

2. Sales status, $\Delta\delta(Y > 0)$
3. Profitability status, $\Delta\delta(L > 0 \ \& \ Y > 0)$
4. Purchases status, $\Delta\delta(M > 0)$
5. Employment, $\Delta \ln L$
6. Worker retention rate (of pre-quake workers)
7. Sales, $\Delta \ln Y$
8. Purchases, $\Delta \ln M$
9. Break-even status, $\Delta\delta(\pi \geq 0)$ conditional on $L > 0 \ \& \ Y > 0$
10. Profitability, $\Delta\pi$ conditional on $L > 0 \ \& \ Y > 0$

From the date of the first major quake (September 2011) onwards, effects are calculated and reported on a monthly basis.[11] The pre-event time period ($t = 0$) against which outcome changes are measured is the average over the five months from April 2010 to August 2010 to align the period to the predominant start of the 2010/11 financial year.[12] The population is constrained to private-for-profit firms that are active, which is defined as employing and having sales at some point during $t = 0$.[13,14]

Table 1 shows the matching variables and the firm cell counts before Auckland-Hamilton firms are reweighted.[15] Industry matching is at the one-digit (division) level, whilst there are five firm size groups, with the two

[11] PAYE data is filed monthly. The default GST filing frequency is two-monthly and is used by 84% of Christchurch firms. We adopt Statistics NZ's apportionment method, which uses industry-level seasonal patterns observed from monthly filers. We include detailed industry-month dummies in all regressions which will tend to unwind this allocation process. Six-monthly filers, for whom Statistics NZ allocates sales and purchases evenly over the filing period, make up only six percent of Christchurch firms (the remaining 10% are monthly filers), so are unlikely to have a major impact on monthly estimates. These firms are, under Inland Revenues rules, necessarily smaller businesses which may introduce some noise to estimated timings of the small firm population. GST sales and purchases are adjusted to be GST-exclusive.

[12] An exception is made for profitability. Since this measure is noiser, the pre-event measure is taken as the simple average over the (partial) $t = 0$ year and the two preceding financial years.

[13] An exception is made for the 102 firms in Finance (K73 under ANZSIC'96) and Services to Finance (K751), since financial services do not attract GST. These firms are included in the employment analysis if they employ in the pre-quake reference period.

[14] Working proprietors paid through the PAYE system are excluded from L.

[15] All counts are random-rounded in accordance with Statistics NZ confidentiality rules. This rounding leads to minor inconsistencies across tables.

largest groups ($L_0 > 10$) further distinguished by whether they have multiple employing locations. Historical employment growth is used as a matching variable, and this is calculated as the log change employment between L_0 and L_{-2} (ie, the financial year April 2008 to March 2009) allocating entering firms to separate cells based on their start year. Matching on employment growth is done within employment level cells, since small and large firms have quite different employment growth distributions.[16] In all subsequent analysis, Auckland/Hamilton firms carry a weight inverse to their cell-level ratio, accounting for the fact that the control region is, eg, more heavily skewed towards property and business services than Greater Christchurch.

Overall, there are almost three control firms for every Christchurch firm, though on a univariate basis this ratio can vary substantially (Table 1 column 3). In particular, large multi-location firms have the fewest comparators. This occurs because large multi-location NZ firms have a tendency to be represented in both Christchurch and Auckland. Because all firms like this are allocated to the Christchurch group, that leaves no similarly large firm to act as controls. Since this preferential allocation is more pronouced the larger firms are, we impose a common support criteria on firm size whereby we drop Greater Christchurch firms that are larger than the largest available control firm. By doing so, we believe that we can assert comparability in the large multi-location firm cells. Common support also applies to other cells, in the sense that we drop any firms that do not have a control firm with the same (industry and employment level/growth) characteristics.[17]

Table 1 reflects population size after the common support criteria have been applied. Table 2 shows the effect of these restrictions on Greater Christchurch firm counts and total employment, together with the impact of other minor cleaning of the data that removes extreme values (in sales and wages) and drops micro enterprises ($L_{-1} < 1$). The largest employment loss (around 6%) comes from imposing the upper bound on L_0 for the largest firms. While dropping micro enterprises results in a substantial loss of pre-quake firms (almost 10%), there is a much smaller employment loss. In reality, many of these firms have actually exited prior to the September quake, since an average employment less than one must be associated with at least one month with zero employment. The loss associated with missing (or very low) GST sales data is minimal (less than 2% of employment), reflecting the high coverage rate this data has for employing firms. Over-

[16] For example, it is much easier for a one employee firm to double in size than it is a 50 employee firm.

[17] Out of the 840 (=15 industries×8 firm sizes×7 growth rates) potential cells, we have 582 permutations containing both Greater Christchurch and control firms.

all, after cleaning and matching, we are left with around 85% of pre-quake private-for-profit employing Greater Christchurch firms, capturing over 90% of the associated employment in the region.

Within Greater Christchurch we wish to separately identify firms more heavily impacted by the effect of the quakes. To do this, we make use of the Earthquake Support Subsidy (ESS), which was established to assist firms wishing to continue employing, but which couldn't meet the wage bill because of the earthquakes. The subsidy ran from 22 February 2011 for up to six weeks, paying $500 per week per full-time employee. Linking is done on the basis of tax numbers and, therefore, is of a very high quality. This data has the advantage over, say, land damage information in that it factors in infrastructural loss or network effects (eg, loss of adjacent businesses or supply chains) in assessing the impact on firm turnover.

The key disadvantage of using the subsidy data is that it does not give a complete picture of the most affected firms. In particular, a business owner may decide to immediately exit post-event and, therefore, be heavily affected but not a subsidy recipient. Importantly, also, the subsidy was limited to firms with less than 50 employees. We expect, however that the geographic location of recipient firms provide a good indicator of whether firms not receiving the subsidy are heavily affected. With that in mind we form two groups for most of the analysis: firms in locations where the majority of eligible (ie, less than 50 employee) firms received the ESS; and firms not in these areas.[18] We hypothesise that the effect of the quakes should be weaker for this latter group, while the effect on non-recipients in heavily affected areas may be stronger or weaker than that of recipients.

Figure 1 shows the geographic distribution of recipient firms – the upper panel showing Greater Christchurch, while the lower panel shows Christchurch City.[19] Many recipients were clustered in and around the Christchurch CBD, but this was not the only area where the majority of businesses were hit hard.

Aside from the heterogeneity imposed by the geography of the event, we break down firms on the basis of a number of pre-existing characteristics

[18]Location is measured at the meshblock level, which is the most detailed available, and approximately corresponds to a city block in dense urban areas.

[19]While the subsidy was limited to firms in Christchurch City Council area, there appears to be some spillover of payouts into adjacent areas affected by the quake. The fact that the subsidy was limited to specific locations does not present a problem if the boundaries were chosen accurately to include all areas where firms might be expected to be badly affected.

to examine heterogeneity in outcomes. Specifically, we estimate separate effects for firms based on size (including single- versus multi-location status); industry; business ownership type; and profitability. To account for the fact that matching is conducted within broad cells (particularly for industry), all regressions include controls for pre-quake ($t = 0$):

1. log employment, as a piecewise linear function for small ($L_0 \leq 10$), medium ($10 < L_0 < 50$) and large ($L_0 \geq 50$) firms
2. log average wage
3. Multi-location status, as a binary dummy variable
4. Employment growth, including a separate binary dummy variable for entrants
5. log firm age
6. profitability[20]
7. business type, as a set of binary variables that account for business type, foreign ownership and domestic enterprise group membership
8. industry, as a set of 146 (three-digit ANZSIC'96) dummy variables

Table 3 shows pre-earthquake summary statistics for Christchurch firms and the (weighted) control group. After weighting, the two groups have very similar average characteristics. In levels, noticeable differences remain in average employment size, arising from the same issue that led to imposing the common support in the large firm employment group. Average monthly wages are higher in Auckland/Hamilton perhaps reflecting a higher cost of living in Auckland (ie, these figures are not adjusted for regional price differences). Despite a 10% higher average wage, firms in Auckland/Hamilton are similarly profitable to Greater Christchurch firms with a 79% likelihood of breaking even, compared with 81% for Christchurch, and a return of 13 cents in a dollar of sales, compared to 14 cents for Christchurch firms. Any effect these pre-existing characteristics have on subsequent firm-level outcomes is removed by directly controlling for them in DID regressions.

Table 3 also reports firm-level characteristics associated with the ESS, shown graphically in figure 1. Forty-three percent of Greater Christchurch firms were recipients under the scheme, while 85% of firms were in a location

[20] Averaged over $t - 2$ to $t = 0$ since this variable is naturally more volatile than other controls.

where at least one eligible firm received the subsidy.[21] We turn now to examining the average effect of the earthquakes on firm performance, and the heterogeneity in the effect by various characteristics including the effect of location using the ESS data.

4 Results

To maintain the most flexibility in the additional control variables (including industry dummies) a separate regression is used to estimate each (of ten) outcome in each (of 25) post-quake months. That is, for example, the effect of pre-quake firm size on survival is allowed to vary over time. Average effects are then disaggregated along a number of dimensions. Because of the volume of estimates this creates, most DID estimates are presented in graphical form, without reporting the relationship between outcomes and control variables. Interpretation of results focuses on effects significantly different from zero at the 5% level or better. To give a sense of the underlying analysis, and the purpose of the controls, we begin the discussion of average effects with an example of the underlying regression results.

4.1 Average impact on Greater Christchurch firms

Table 4 reports ordinary least squares regression coefficients for whether a firm continues to employ, assessed at six-monthly intervals starting with the month of the first major earthquake (September 2010) and ending at the last analysis month (September 2012).[22]

The top row of the table reports the effect of the earthquakes – being the estimated coefficient on an indicator variable for having a location in the Greater Christchurch region. To recap, the dependent variable is the change (difference) in employment status, and the indicator variable picks up the initial difference in location, hence difference-in-difference (DID). At the time of

[21] Consistent with the employment criteria for ESS, recipients are smaller than non-recipients. Specifically, the average ESS recipients had 9.6 employees prior to the earthquakes and were more likely to be single-location and, therefore, have a higher average employment share in Greater Christchurch (97.5%).

[22] All regressions are OLS (with robust standard errors), regardless of whether the change in the outcome could be modelled explicitly as a binary or ternary variable. A binary change variable arises for status outcomes that are constrained to be one in the pre-quake period (employment, sales and profitability status), while the ternary change variables results from the other status outcomes (purchases and break-even status).

the first major quake (column 1), there is no difference between Christchurch and Auckland/Hamilton firms. This is a picture we see with most results, consistent with the first major quake having little immediate impact on business outcomes. Importantly, if the initial impact was actually moderate, this result also implies that the matching and control process has achieved the desired outcome – that is, it is akin to showing that Christchurch and control firms have similar outcomes over some pre-event period where there is no expectation of differences being apparent between the two groups.[23]

After the second major quake, in February 2011, Greater Christchurch firms are initially 1.2% less likely to be employing, falling further to -2.6% in September 2011, before recovering to 1% less likely in September 2012. Because these are DID results, the decline in effect could be due to the restarting of Greater Christchurch firms that temporarily stopped employing and/or a slower rate of firm exit (from employing) in the latter period, relative to Auckland/Hamilton. A relatively low exit rate might be expected if the earthquakes initially accelerated the exit of Greater Christchurch firms that would have exited anyway at some later date – an idea we return to when we consider variation in survival rates by prior performance.

The other control variables show results consistent with expectation. Larger and older firms are less likely to exit. The effect of firm size diminishes with firm size, but increases with time, reflecting the lower survival rates for small and young firms. Consistent with exit being related to performance, firms that had been growing more rapidly (over the three years prior to the quakes), paid higher wages, and had higher prior profitability were more likely to continue employing. Since all regressions include three-digit industry dummies, these relationships can be interpreted as relative performance within industry. Perhaps surprisingly, multi-location and group member firms are more likely to cease employing though, as these firms are generally large, their overall exit rates are lower than small firms.

The full path of the effect of the earthquakes on employment status (with 95 percent confidence interval), is shown in panel A of figure 2, together with other survival outcomes. The remaining performance variables are shown in figure 3. For the former, outcomes are estimated for the entire population of firms, while changes in the latter group of performance variables is only estimated for the surviving sub-population (as measured by the

[23]Since these results support the adequacy of the matching procedure, we do not test whether matching at an earlier period would produce zero estimated effects for a pre-September 2010 period.

corresponding status variable as at each month).[24]

As with employment status, there is an immediate drop in the likelihood of having sales and purchases following the February earthquake (panels B & D) with a subsequent recovery resulting in having sales being 1.2% less likely by September 2012 (significant at the 1% level). Panel C combines employment and sales status results – at its low point (July 2011) 3.3% fewer firms are both employing and selling goods or services.

Conditional on continuing to employ, average employment briefly dips below expected levels, before ending 4.5% above the level of similar Auckland/Hamilton firms (panel A of figure 3). Panel B shows that the recovery in employment is not achieved entirely through reemploying pre-quake staff with firm-specific work experience significantly, and seemingly permanently, 3% lower than control firms. Firms that survive the initial sharp negative output shock – an average 9% drop in sales – also experience a steady increase in sales, relative to what might be expected in the absence of the quakes (ending at 7.2% above control). Partly as a consequence of the different dynamics of sales and employment, firms initially suffer a decline in profitability (panels E & F). The most startling effect in these statistics is the rapid return of profitability to the status quo. In 11 of the 18 months from April 2011, the effect on the profit rate is insignificantly different from zero (at the 5% level). This is despite the fact that surviving firms are, on average, larger and with sales increasing at a faster rate than employment and purchases which, ceteris paribus, would act to increase the profit rate.

These average effects conceal marked differences in outcomes across firms. The next subsection begins the process of unpicking these differences by focussing on the effect the geography of the February event had on the intensity of the shock, and subsequent outcomes, experienced by firms.

4.2 Heterogeneity across Greater Christchurch firms

4.2.1 Geography and the ESS

To get an initial sense of the location-specific heterogeneity in firm outcomes, we restrict attention to firms eligible to receive the ESS – assumed to be all firms with less than 50 employees prior to the September 2010 earthquake. One complication associated with direct use of the ESS data is that, in order

[24] For example, change in break-even status is only estimated for firms with both sales and employment (ie, that have profitability status equal to one in the month).

to be eligible to receive the subsidy, a firm must have been employing when the second major quake struck. Figure 4 demonstrates the problem this poses in interpreting differences in outcomes between recipients and non-recipients, using employment status as the outcome of interest. The solid line represents the effect of the quakes for ESS recipients on their employment status.[25] The dashed line shows the effect in more subsidised areas for firms *not* claiming the subsidy – that is, other firms that might be expected to have been badly affected. Comparison of these two groups shows an apparent 10 percent difference in employment survival rates just *prior* to the February quake (ie, the gap between the two lines in January 2011). At least some of this gap must be due to the survival-based eligibility criteria since there is also a *positive* 6% employment survival difference between recipients and firms in "unaffected" locations (ie, where no firm claimed the subsidy) before the February 2011 quake, which seems unlikely.[26]

Since the aim of this subsection is to motivate the use of the ESS data as a valuable tool for determining geographic variation in impact intensity, we address this issue by making a further population restriction and only include firms still employing in January 2011. This approach has the effect of ignoring any true difference in outcomes between these groups caused by the first major earthquake. Based on the average results (figures 2 and 3), these effects are relatively minor, though that does not ensure that they are small for all subgroups.

Figures 5 and 6 show effects on survival and performance, respectively, for the subset of firms deemed eligible for the ESS – ie, those with less than 50 employees at $t = 0$ and still employing in January 2011. The addition of the January survival criteria can be seen in panel A of figure 5 where, by construction, the effect is assumed to be zero for all subgroups. From this panel, we can see more clearly the difference in employment survival rates between firms in heavily affected regions receiving and not receiving the subsidy.

These results appear to show that the ESS did not enhance the employment survival chances of recipient firms, relative to similar firms also in heavily affected regions, for a substantial period beyond the six week life of the subsidy (panel A, figure 5). Further, ESS firms were less likely to hold onto their initial employees (panel B, figure 6), despite staff retention being

[25] Confidence intervals are no longer reported because of the number of subgroups.

[26] Since the first major quake does not appear to have had a measurable effect on employment survival, it seems unlikely that this latter gap is explained by differences in the geography of the September and February quakes.

an explicit goal of the scheme.

However, while we control for many firm characteristics, this analysis does not constitute a proper evaluation of the scheme, primarily because we make no attempt to explain why some firms seek the subsidy and others don't, within heavily affected locations. Figures 6 makes the importance of this caveat clearer – ESS recipients experienced much larger drops in sales, purchases and profitability immediately after the February quake. In this sense, the receipt of the subsidy indicates a particularly badly affected firm from a financial perspective. This finding was not inevitable since, for example, the worst affected firms may have exited immediately, rather than trying to continue to operate, in which case we might have expected the (financially) worst affected firms to be those in heavily affected locations that *did not* receive the ESS.

In sales growth terms (panel C of figure 6), the gap between recipients and non-recipients in heavily affected locations was substantial – 13% in February 2011 – suggesting the policy was appropriately targetted towards firms most likely to have experienced trouble meeting their wage obligations. In fact, the ESS subgroup was the only one to experience a significant decline in profitability, continuing for the four months from February-April 2012 (significant at the 1% level in each month).

Overall, these results show that the location of ESS firms usefully maps out the geography of the impact on firms. For the remainder of the subgroup analysis, we revert to considering all firms, including those with 50 or more employees. Since large firms could not access the ESS, we define location-specific earthquake intensity using the share of eligible firms receiving the ESS. Roughly speaking, firms in low/zero ESS share locations experienced similarly weak effects, suggesting a logical break at 50% – that is, locations with less than half of eligible firms receiving the ESS are deemed "low" impact intensity areas, whereas locations with 50% or more of eligible firms receiving the ESS are in "high" impact intensity areas. This distinction helps control for potential confounding factors between geography and industry, say, which may have a geographical dimension.[27]

[27]For example, the average effect of the quakes on farms may appear weak because they were not present in the CBD.

4.2.2 Firm size

We begin the analysis of subgroups by simultaneously considering heterogeneity in two related characteristics – firm size and the geographic concentration of employment. Specifically, we separate Greater Christchurch firms into small, medium and large firm size groups, and then further separate the medium and large firms into those with all their employment in Greater Christchurch, those with 20% or more of their total employment in Greater Christchurch, and those with less than 20% or more of their total employment in Greater Christchurch.[28] Table 5 shows the number of firms in each group together with the proportion of each firm type with a location in the high impact intensity area. Overall, slightly over half of firms are in a high impact area with multi-location firms more likely to have at least some of their employees working in these locations.

Figures 7 and 8 show effects on survival and performance, respectively, by firm size and the share of employment in the Greater Christchurch area. The left column in each figure shows results for firms in low impact intensity areas, and the right column the high impact intensity areas. The main point to take from figure 7 is that firms completely ceasing employing (change employment status) are primarily small and medium-sized firms in high impact areas. In contrast, contraction of employment – short of the point of exit – is more evident in large firms and to a lesser extent medium-sized firms in high impact intensity areas (right of panel A, figure 8). Further, that impact is experienced primarily by larger firms that had no plants located outside the Greater Christchurch area prior to the quakes. This differential effect may, partly, be due to simple algebra since the outcome variable is total firm employment across all regions. If the impact on Christchurch employment was equal for all large firms, this would show up as a stronger impact on Christchurch-only firms simply because they have a greater share of employment exposed to the impact. Unfortunately, we cannot completely unpick whether geographic diversity is a mitigating factor because the LEED data cannot be used to accurately track the movement of workers between plants owned by the same firm.

The largest apparent negative impact on sales and purchases is for large, high Christchurch share, firms in low impact areas, though this effect is only significantly different from zero (at the 5% level) in the last five months of data. Outside of that group, comparison of the left and right-hand figures in

[28] Twenty percent is chosen as the break point to allow sufficient observations in the relevant large firm group.

panels A-D of figure 8 suggests a general pattern of the recovery resulting in resources shifting to the low impact intensity areas, without a clear pattern as to which sorts of firm are beneficiaries (that is, the slopes of low impact effects over time are less negative than for high impact areas). Finally, panels E and F demonstrate that there is very little effect on profitability, conditional on survival. Significant negative measured profitability impacts are restricted to small firms in high impact areas, and even then, the effect is limited to the three months from February to April 2011.

4.2.3 Business type

Firm size and geographic scope is also clearly related to business type. In particular, 91 (98) percent of partnerships (sole proprietorships) are small firms. Since separating firms by business type as well as firm size and Christchurch employment share would produce too many categories to be manageable, we now split firms separately by business type combined with (binary) multi-location status. We expect the small firm results to be apparent in ownership type but with, perhaps, interesting variation between sole proprietorships and partnerships.

Table 6 reports ownership type by intensity area. Single location independent limited liability companies are the most common business type because we require firms to have employees. This table also shows that slightly more than half of multi-location firms are in enterprise groups under either domestic or foreign-ownership. This adds another dimension to the potential impact on such firms, since their wider network could be positive for own-firm performance (if, say, internal finance is easier to access than external finance) or negative for performance (if, say, activities can be taken over by parts of the group in unaffected locations).

Figures 9 and 10 show effects on survival and performance, respectively, by business type. In this section, we focus exclusively on the high impact area effects, as the low impact results show little variation by business type. Consistent with expectation, the small employment business types of sole proprietorships and partnerships show the strongest negative impact on survival (right-hand side of panels A-C, figure 9). Interestingly, partnerships fail to recover to the same extent as sole proprietorships. For example, the former group still has a -7.2% effect on employment survival (significant at the 1% level), compared with a -3.8% effect for sole proprietorships (insignificantly different from zero at the 5% level), in September 2012. Speculatively, this could be due to the need for greater coordination in partnerships, where mul-

tiple parties need to agree to continue operating for the business to survive. While not as obvious from the graph, single location independent companies also have a significant (at 5% level) negative impact of -1.4% in September 2012. In employment terms, this group is most like partnerships, and may face a similar coordination issue.

Conditional on firm survival, there is less variation in outcome by business type than by firm size (figure 10).[29] Sole proprietorships, partnerships and independent companies experience a particularly large initial negative shock to sales, over and above their heightened exit rates. As with the firm size results, any negative effect on profitability rapidly diminishes post February 2011, with all high impact group break-even status and profitability coefficients insignificantly different from zero by June 2011.

On some metrics, single location foreign-owned firms seem to do particularly badly (employment, sales and purchases growth), though point estimates vary considerably from month-to-month and effects are seldom significantly different from zero (reflecting the small size of this group). Overall, the results provide little support for the idea that group structures lead to markedly different outcomes, either positive or negative.

4.2.4 Industry

Industry is another potentially important dimension over which outcomes may differ. Table 7 shows the distribution of industries by impact intensity area, where we have pooled some industries to maintain reasonable subpopulation sizes. As expected, agriculture is underrepresented in the high impact area, unlike retail trade and the business services group of industries which are both overrepresented in the heavily-affected CBD. Because we still have nine industry groupings, we choose not to report them all graphically, instead focussing on the two extreme cases – construction and accommodation, cafes and restaurants – and the two largest remaining industries, retail and business services, which are also the most concentrated in the CBD (table 7). A subset of results for all industries in selected months is reported in tabular form in the appendix.[30]

Figures 11 and 12 show effects on survival and performance, respectively, for the four selected industries. Comparison between the extremes –

[29] Y-axis ranges are held constant within a figure for comparison, but vary across subgroup analyses.

[30] Complete industry results are available from the authors on request.

construction and accommodation, cafes and restaurants – demonstrates the breadth of heterogeneity in outcomes. Regardless of location, construction firms have improved survival rates (8-10% for employment) and performance outcomes (25-30% for employment, 43-47% for sales, and 37-44% for purchases) at September 2012. Unlike other subgroups, construction firms did not see any impact on the retention of experienced staff (panel B, figure 11) which, presumably, helped mitigate problems associated with growing the workforce so rapidly. These results don't take account the entry of new businesses, which further accelerated changes in the industry structure of the region (Statistics New Zealand 2014a).

At the other extreme, survival of accommodation, cafes and restaurants is negatively affected both inside and outside the high impact area, with little sign of recovery over time. In the high impact intensity area, the probability of continuing to employ initially falls by 24%, recovering slightly to end the period at 20% below control, while sales survival drops by around 15% and remains at that level. In addition to large scale exit from trading, surviving firms in the high impact area take a large hit to both employment and sales, with the latter halving almost immediately following the February quake. Purchases fell even further, with an average decline of 80% – given that many businesses in this industry might be expected to hold perishable stocks, this may be indicative of an even greater decline in sales than suggested by the tax data.[31] In contrast, sales actually rise for surviving firms in the low impact area, presumably in part because these firms picked up customers that were formerly serviced by exiters or firms in the high impact area. Finally, the rate of loss of experienced staff rises by 29%, over and above the traditionally high staff turnover rates in the industry (since industry fixed effects are included in all regressions), settling at 17% lower by the end of period.

The additional large industry groupings – retail trade and business services – experience similar performance outcomes to each other, conditional on survival. However, in the high impact area, retail businesses have somewhat lower survival rates compared to business services firms. Several mechanisms might explain these differences: retail firms may be more exposed in the high impact area because of a dependence on walk-up trade, which could have been impacted by damage to transport infrastructure, the cordon and/or by the effect of the closure of other businesses on foot traffic;[32] business services may be easier to relocate and/or to continue operating with staff working from

[31] For example, because some "sales" may result from liquidating recoverable assets, rather than from goods or services

[32] See, eg, Haltiwanger et al. (2010) for evidence on this spillover effect.

home; and/or demand may have been relatively weak for some retail goods following the second major quake. The results for the hospitalities sector support the hypothesis that the geographic location of immobile capital had a large impact on relative outcomes.

Perhaps remarkably, given the marked disparity in industry dynamics, effects on profitability are muted. All reported industries in the high impact area are negatively affected in February 2011, but this effect dissipates by April 2011. Accommodation, cafes and restaurants in the low impact area, have significantly higher measured profitability over February 2011 to May 2012 (peaking at 11% above expectation), consistent with increased demand for these services and, in the short-term, significantly lower supply. The final table in the appendix, shows the estimated effect on profitability for each industry in February 2011, with six out of the nine industries having significant negative effects in high impact areas (column 2, bottom panel). By the following September (column 3), only one industry still had a negative coefficient (significant at the 5% level), mining and manufacturing, and in this case the coefficient is insignificantly different from zero for the three months either side of that date.[33] This pattern of a rapid return to normal profitability, conditional on survival, is explored in more detail in the next subsection, where we consider the role of prior profitability in determining which firms survive.

4.2.5 Profitability

For the final subgroup analysis, we separate firms based on whether they achieved break-even over the three years prior to the first major earthquake and, for firms that did, further divide the population into those firms with returns below 20 cents in the dollar, and those at or above that point. Table 8 shows the number of firms in each group, as well as a small population of finance industry firms for which these measures cannot be calculated.[34] Eighteen percent of Greater Christchurch firms with the relevant tax data are estimated to fall below the break-even point prior to the earthquakes, with a further 44 percent having positive returns less than 20%. There is no apparent sorting on profitability by location (ie, all high impact shares are

[33] Business services firms located in the high impact area experienced a significant positive effect in both September 2011 and September 2012, with that effect extending for 10 out of the 14 months from August 2011 to September 2012.

[34] This latter group are retained in the employment-related regression analyses, with separate (unreported) estimated Christchurch coefficients.

close to the population average) consistent, perhaps, with land prices having an equalising effect on profits.

Figures 13 and 14 show effects on survival and performance, respectively, by prior average profitability.[35] Focusing first on survival (figure 13), and concentrating on high impact area results, it is clear that longer-term survival effects are restricted to firms previously below the break-even point. Low profitability firms are roughly 9% more likely to have ceased employing and around 6% less likely to be selling goods and services.[36] Observed selection could be due to some firms' profitability being shifted below a threshold at which their business is viable and this threshold being closer for low profitability firms and/or the shift in profitability being more substantial for low profitability firms. Alternatively, it could be that profitability is related to accumulated cash reserves and/or the ability to raise external (debt or equity) capital. Firms in the two positive profitability categories experience very similar survival effects, suggesting that if it is the former mechanism then this threshold effect binds below the break-even point (as measured using our proxy). A negative threshold value for exit would also be consistent with observing a substantial proportion of the sample with below break-even levels in the three years prior to the earthquakes.

Conditional on survival, low prior profitability firms in high impact areas also have worse employment and sales outcomes. Employment bottoms out at 10.8% lower before recovering to -3.5% by September 2012, while sales drop an average 24% before recovering to -7.7%.[37] In contrast, the earthquakes result in surviving (historically) profitable firms being, on average, larger in September 2012 in terms of both employment (4-8% higher) and sales (8-11% higher), regardless of location (all results significant at the 1%

[35] We report break-even status effects differently in this subsection to account for the fact that the group definitions impose constraints on the value of the change in the outcome. Specifically, firms initially below the break-even point can only have actual changes of break-even status in the set $\{0, 1\}$, whereas the other two groups can only have changes in $\{-1, 0\}$. This difference results in a large levels difference in estimated coefficients, which is not fully accounted for by the inclusion of the (continuous) lagged profitability variable in the set of controls. To aid interpretation, we subtract from each series the average of the estimated effects from September 2010 to January 2011. This adjustment is not required for the estimated effects on profitability because of the inclusion of lagged profitability as a control variable.

[36] For employment status, negative estimated effects are significantly different from zero at the 5% level in February 2011, and at the 1% for all subsequent months. For sales status, effects are significantly different from zero at the 1% level in all months from February 2011, inclusive.

[37] Results are negative and significantly different from zero at the 5% level for employment (sales) in 18 (14) of the 20 months from February 2011 to September 2012.

level).

These results are consistent with persistent differences in management or staff capability. As Fabling and Grimes (2014) found for NZ businesses, management practices can have a material impact on relative firm performance. It is plausible that these practices – or the managers who put these practices in place – also have a tangible effect on the ability of firms to be resilient and to recover after unexpected shocks.

In high impact areas, and directly after the second major quake, profitability is lower (significant at the 1% level) for all firm types. By June 2011 the negative impact has fully dissipated, with the most profitable firms then significantly above their pre-quake average – an effect that persists through to September 2012.[38] Firms initially below the break-even point have a significantly positive profitability effect in the low impact zone, perhaps reflecting a windfall gain to unaffected firms previously operating at below capacity, though this effect eventually fades and is only sporadically statistically significant from March 2012 onwards.

5 Conclusions

This paper has uncovered wide variability in earthquake outcomes for firms. Such results, hopefully, will lead to better estimates of the potential outcomes of natural disaster events in other locations, by allowing the distribution of firm characteristics in high risk zones to be accounted for.

In particular, we have shown that initial profitability differences between firms led to different dynamics following the second major earthquake. Poor performers are disproportionately, and strongly, selected to exit. In contrast surviving firms, generally speaking, rapidly revert to status quo profitability levels. Both results are consistent with competition acting to prevent extreme profits, and to eliminate poor performing firms – with the latter process accelerated by the Canterbury earthquakes.

This work suggests a number of potential research avenues. Firstly, the profitability results could be better understood by examining the role of capital reserves, and also of management practices, in determining firm resilience. Secondly, a formal evaluation of the ESS could yield insights

[38] Significantly different from zero at the 1% level in 14 of the 16 months.

into the role of such a scheme in the case of future events.[39] Thirdly, while this paper has looked at firm exit, particularly of sole proprietorships and partnerships, it has not considered what those entrepreneurs do subsequently. The decisions of these individuals may be an important factor in determining subsequent regional growth. Fourthly, considering the heterogeneous effect on firms, it seems natural to also ask about variation in outcomes for workers, particularly those whose employer was forced to exit. Statistics NZ data allow a number of outcomes to be tracked over time, including job-to-job and job-to-benefit transitions as well as internal and foreign migration. Finally, in time, these results should be updated to test whether effects continue to persist over the longer term, a process that is facilitated by the annual updating of the LBD.

[39] This evaluation could exploit the fact that the scheme was restricted to firms with less than fifty employees, which opens the possibility of using a regression discontinuity design to determine effects.

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Tables & figures

Table 1: Unweighted firm counts by each cell characteristic

	(1) Greater Christchurch	(2) Auckland/ Hamilton	(3) Ratio (2)/(1)
Industry			
[A] Agriculture, forestry & fishing	807	735	0.911
[B] Mining	6	6	1.000
[C] Manufacturing	1,350	3,750	2.778
[E] Construction	1,506	3,819	2.536
[F] Wholesale trade	1,062	3,612	3.401
[G] Retail trade	2,028	6,501	3.206
[H] Accommodation, cafes & restaurants	876	2,358	2.692
[I] Transport & storage	459	1,242	2.706
[J] Communication services	45	153	3.400
[K] Finance & insurance	180	525	2.917
[L] Property & business services	1,854	6,621	3.571
[N] Education	159	438	2.755
[O] Health & community services	690	2,031	2.943
[P] Cultural & recreational services	171	561	3.281
[Q] Personal & other services	441	1,263	2.864
Lagged employment level (L_0)			
$L_0 = 1$	1,932	6,204	3.211
$L_0 \in (1, 3]$	3,171	9,933	3.132
$L_0 \in (3, 5]$	1,662	5,139	3.092
$L_0 \in (5, 10]$	1,914	5,808	3.034
$L_0 \in (10, 50)$ & single location	1,434	4,782	3.335
$L_0 \in (10, 50)$ & multiple location	663	876	1.321
$L_0 \in [50, \infty)$ & single location	171	504	2.947
$L_0 \in [50, \infty)$ & multiple location	681	363	0.533
Lagged employment growth ($t = -2$ to $t = 0$)			
Entrant at $t = -1$	909	3,162	3.479
Entrant at $t = 0$	240	843	3.513
Below median negative growth in L_0 cell	2,427	6,750	2.781
Above median negative growth in L_0 cell	2,451	6,567	2.679
Zero growth	1,062	3,186	3.000
Below median positive growth in L_0 cell	2,418	6,534	2.702
Above median positive growth in L_0 cell	2,118	6,573	3.103
Total firms	**11,628**	**33,615**	**2.891**

Cells for weighting Auckland/Hamilton observations are interactions of the three panels in this table, that is industry × employment level × employment growth.

Table 2: Effect of data cleaning on coverage of firms and employment

	Greater Christchurch		Proportion	
	Firms	L_0	Firms	L_0
Excluded from analysis				
Larger than largest Auckland/Hamilton firm	9	7,700	0.001	0.061
Micro enterprises ($L_0 < 1$)	1,356	670	0.099	0.005
Zero sales in industry where sales expected	240	1,400	0.017	0.011
Sales below $5,000 per month	453	940	0.033	0.007
Average wage below $100 per month	12	15	0.001	0.000
Average wage above $20,000 per month	9	75	0.001	0.001
No Auckland/Hamilton firm in cell	39	1,600	0.003	0.013
Total excluded	**2,118**	**12,400**	**0.154**	**0.098**
Included in analysis	11,628	114,600	0.846	0.902
Total firms	**13,746**	**127,000**	**1.000**	**1.000**

Population is private-for-profit firms with an employing location in Greater Christchurch over the period April 2010 to August 2010. L_0 is average employment over the period April 2010 to August 2010.

Table 3: Pre-earthquake ($t = 0$) summary statistics

	Greater Christchurch		Auckland/Hamilton	
Variable	Mean	St. dev.	Mean	St. dev.
Annual sales	646,291	5,488,667	601,982	4,777,657
Annual purchases	467,418	4,493,312	465,001	4,350,616
Average monthly wage	2,801	1,536	3,094	1,842
Employment level	24.37	116.1	17.38	75.82
ln(Annual sales)	11.14	1.612	11.20	1.559
ln(Annual purchases)	10.55	1.793	10.62	1.721
ln(Average monthly wage)	7.766	0.642	7.856	0.647
ln(Employment level)	1.617	1.397	1.589	1.328
Employment growth	0.049	0.558	0.054	0.574
Average profitability (return on sales)[§]	0.144	0.271	0.131	0.281
Break-even firm ($\delta(\pi \geq 0)$)[§]	0.815	0.388	0.788	0.409
Age (years since first observed employing)[†]	7.720	3.886	7.637	3.890
Business type				
Domestic independent (non-group) company	0.710	0.454	0.730	0.444
Domestic company in group	0.073	0.261	0.077	0.266
Foreign-owned	0.058	0.233	0.067	0.251
Partnership	0.074	0.261	0.061	0.240
Sole proprietorship	0.086	0.280	0.064	0.245
Multi-location firm	0.142	0.350	0.136	0.343
Share of employment in Greater Christchurch	0.917	0.245		
ESS recipient	0.430	0.495		
In a location where single-location firm received ESS	0.850	0.357		
Local share of single-location eligible ESS recipients[‡]	0.463	0.292		

All statistics for Auckland/Hamilton firms reweighted to reflect composition of Greater Christchurch firms. § Profitability is measured over the period $t = -2$ to $t = 0$. † Age is right-censored at 137 months. ‡ Maximal share used for firms in multiple Greater Christchurch locations.

Table 4: Average impact of quakes on employment status (subset of months)

Dependent variable	(1)	(2)	(3)	(4)	(5)
Employing in:	Sep-10	Mar-11	Sep-11	Mar-12	Sep-12
Greater Christchurch firm	0.000	-0.012**	-0.026**	-0.021**	-0.010*
	[0.002]	[0.003]	[0.004]	[0.004]	[0.004]
ln(employment)^{sml}	0.019**	0.061**	0.083**	0.095**	0.102**
	[0.002]	[0.003]	[0.003]	[0.004]	[0.004]
ln(employment)^{med}	0.006*	0.012*	0.026**	0.029**	0.035**
	[0.003]	[0.005]	[0.007]	[0.008]	[0.009]
ln(employment)^{lge}	0.005*	0.006	0.004	0.002	0.008
	[0.002]	[0.004]	[0.007]	[0.009]	[0.009]
Medium-sized firm	0.024**	0.084**	0.103**	0.119**	0.117**
	[0.009]	[0.015]	[0.021]	[0.024]	[0.027]
Large firm	0.027*	0.113**	0.181**	0.229**	0.236**
	[0.011]	[0.020]	[0.031]	[0.040]	[0.043]
Employment growth	0.025**	0.025**	0.033**	0.029**	0.034**
	[0.003]	[0.004]	[0.004]	[0.005]	[0.005]
Entering firm	0.021**	0.009	0.003	0.004	0.016
	[0.006]	[0.009]	[0.011]	[0.011]	[0.012]
ln(age)	0.011**	0.018**	0.024**	0.031**	0.042**
	[0.002]	[0.003]	[0.004]	[0.004]	[0.004]
ln(average wage)	0.029**	0.045**	0.049**	0.053**	0.058**
	[0.003]	[0.004]	[0.004]	[0.004]	[0.005]
Average profitability	0.013**	0.040**	0.072**	0.101**	0.106**
	[0.005]	[0.007]	[0.008]	[0.009]	[0.010]
Multi-location firm	-0.022**	-0.020**	-0.019**	-0.020**	-0.021**
	[0.004]	[0.005]	[0.006]	[0.007]	[0.007]
Domestic company in group	-0.013**	-0.019**	-0.027**	-0.028**	-0.046**
	[0.003]	[0.005]	[0.007]	[0.008]	[0.009]
Foreign-owned	-0.010**	-0.019**	-0.016*	-0.026**	-0.037**
	[0.003]	[0.005]	[0.007]	[0.008]	[0.009]
Partnership	-0.005	-0.008	-0.005	-0.003	-0.014
	[0.005]	[0.007]	[0.009]	[0.010]	[0.010]
Sole proprietorship	0.009*	0.009	0.010	0.010	-0.012
	[0.005]	[0.007]	[0.009]	[0.009]	[0.010]
N(firms)	45,234	45,234	45,234	45,234	45,234
R^2	0.041	0.067	0.089	0.097	0.102

Ordinary least squares regression where the dependent variable is the change in employment status from the pre-quake period to the reported month ($0 = (1-1)$ if still employing, and $-1 = (0-1)$ if non-employing, since all firms are initially employing). Robust standard errors are reported in square brackets (**;* denotes significantly different from zero at the 1%;5% level respectively). Firm size categories are small ($L_0 \leq 10$), medium ($10 < L_0 < 50$) and large $L_0 \geq 50$. Reference groups are independent domestic company (for business type), and small firms (for firm size). All regressions include unreported three-digit industry dummies.

Table 5: Distribution of Greater Christchurch firms by size, local employment share and location

	N(firms)		High
	Impact intensity area		impact
	Low	High	share
Small	4,170	4,506	0.519
Medium-sized			
Single location	657	777	0.542
Multi-loc, high Christchurch share	156	261	0.626
Multi-loc, low Christchurch share	84	162	0.659
Large			
Single location	99	69	0.411
Multi-loc, high Christchurch share	87	153	0.638
Multi-loc, low Christchurch share	159	282	0.639
Total	**5,412**	**6,210**	**0.534**

Firm size categories are small ($L_0 \leq 10$), medium ($10 < L_0 < 50$) and large $L_0 \geq 50$. For multi-location firms, high Greater Christchurch share is defined as having at least 20% of employment in the region. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

Table 6: Distribution of Greater Christchurch firms by business type and location

	N(firms)		High
	Impact intensity area		impact
	Low	High	share
Sole proprietorship	531	465	0.467
Partnership	498	354	0.415
Independent company			
Single location	3,456	4,038	0.539
Multi-location	252	507	0.668
Domestic company in group			
Single location	243	252	0.509
Multi-location	153	201	0.568
Foreign-owned			
Single location	93	99	0.516
Multi-location	183	291	0.614
Total	**5,412**	**6,210**	**0.534**

High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

Table 7: Distribution of Greater Christchurch firms by industry and location

	N(firms) Impact intensity area		High impact
	Low	High	share
Agriculture, forestry & fishing	723	81	0.101
Mining & manufacturing	627	732	0.539
Construction	729	777	0.516
Wholesale trade	483	579	0.545
Retail trade	789	1,239	0.611
Accommodation, cafes & restaurants	399	480	0.546
Transport & storage	267	189	0.414
Communication, finance, insurance, property & business services	699	1,377	0.663
Education, health, community, cultural, recreational, personal & other services	699	759	0.521
Total	**5,412**	**6,210**	**0.534**

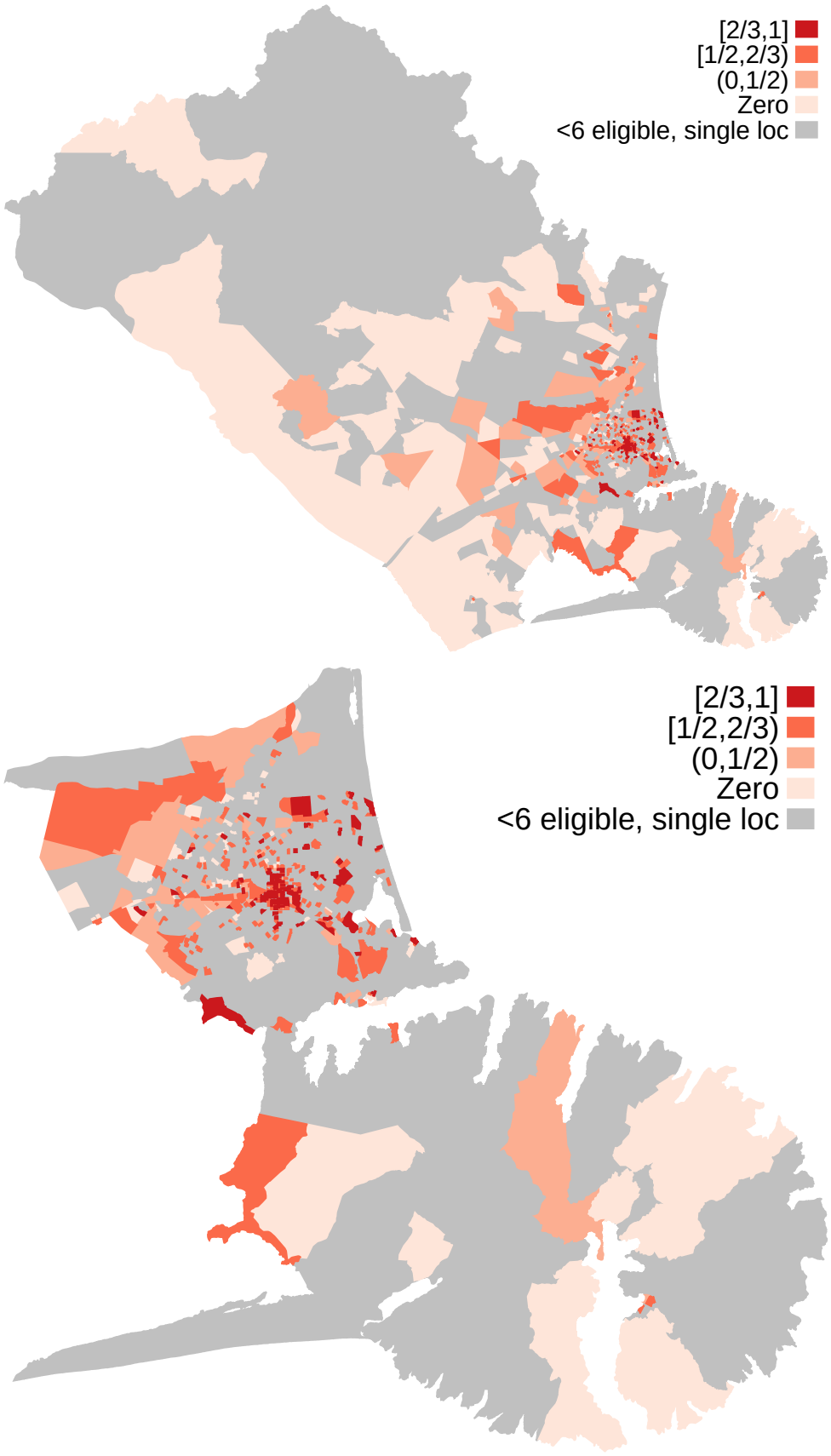
High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

Table 8: Distribution of Greater Christchurch firms by prior profitability and location

	N(firms) Impact intensity area		High impact
	Low	High	share
Non-GST industry	27	75	0.735
Negative profitability	1,023	1,107	0.520
Profitability between break-even and 20%	2,391	2,736	0.534
Profitability at 20% or higher	1,974	2,295	0.538
Total	**5,412**	**6,210**	**0.534**

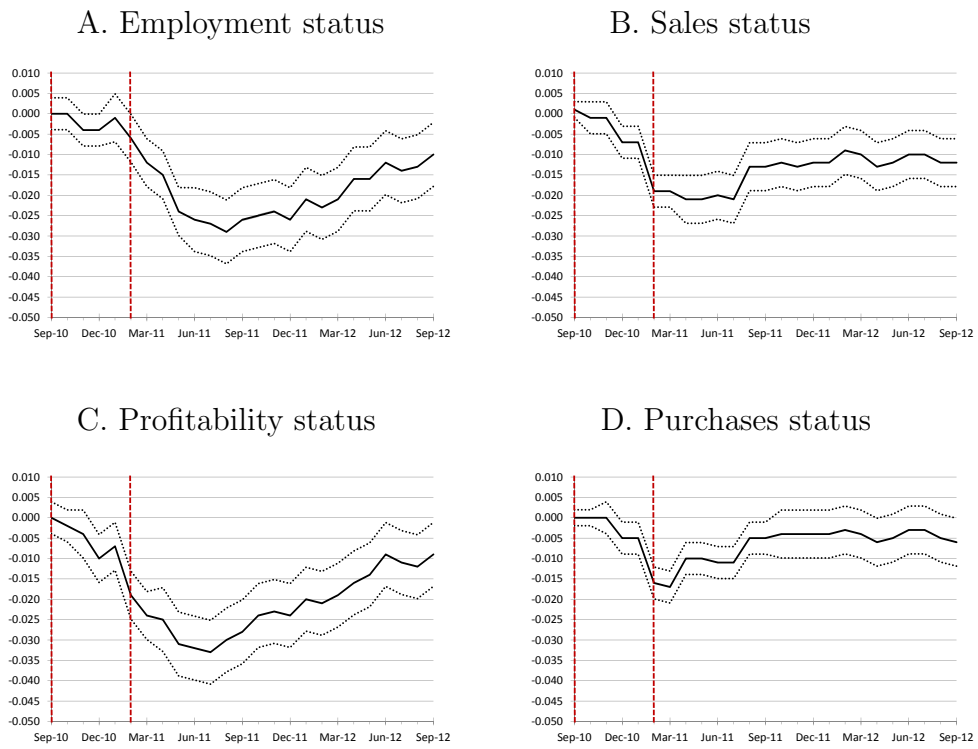
Profitability measured as average return on sales over the three years $t = -2$ to $t = 0$. Non-GST industries are finance (K73) and services to finance (K751). High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

Figure 1: ESS by location – Greater Christchurch and Christchurch City



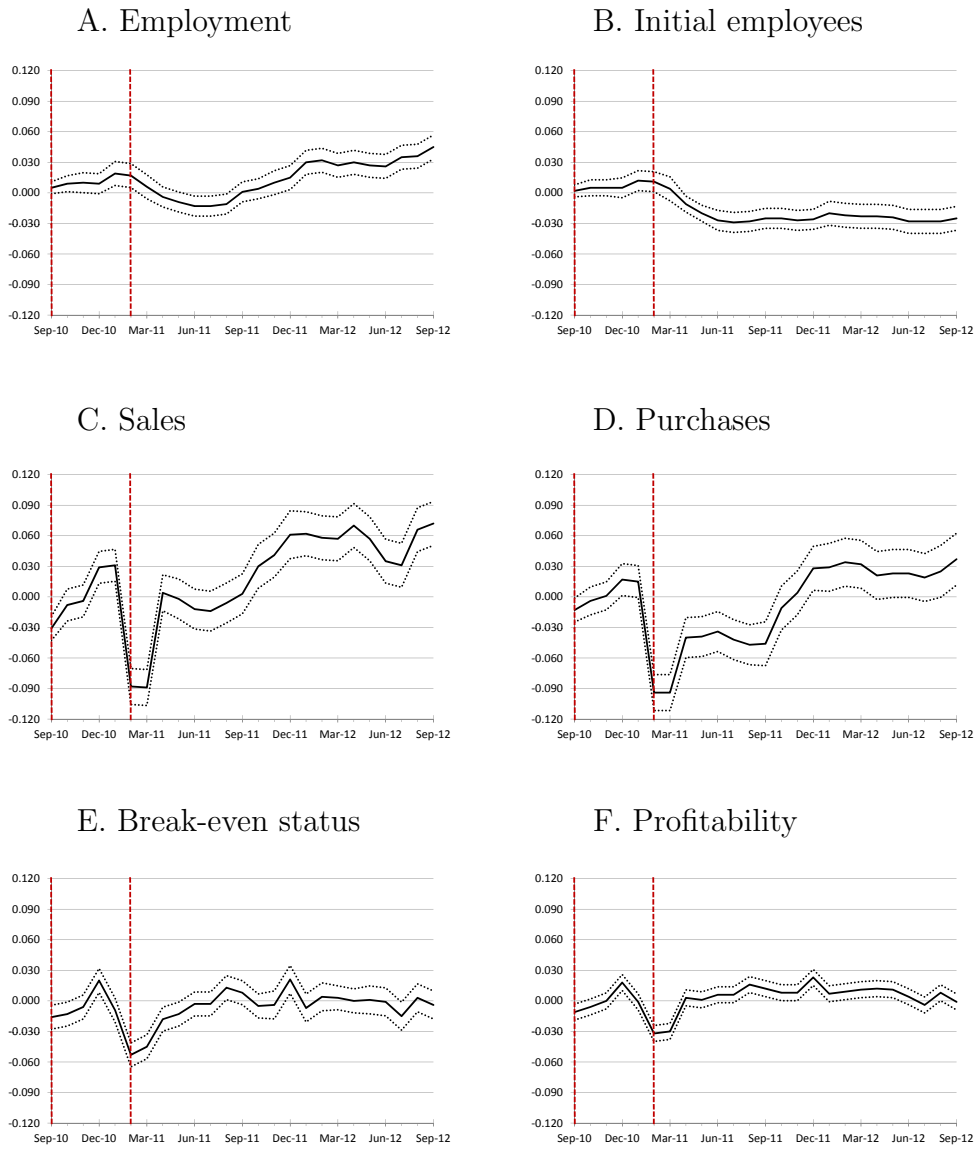
Share of single-location eligible firms receiving the Earthquake Support Subsidy (ESS). In accordance with Statistics NZ confidentiality rules, reported shares are based on random-rounded (base 3) underlying counts. We exclude meshblocks with less than six eligible firms because confidentialisation introduces substantial noise to estimated shares in these locations. In subsequent analysis meshblocks are assigned a status based on actual (unrounded) counts, enabling the classification of all meshblocks.

Figure 2: Average impact of earthquakes on survival



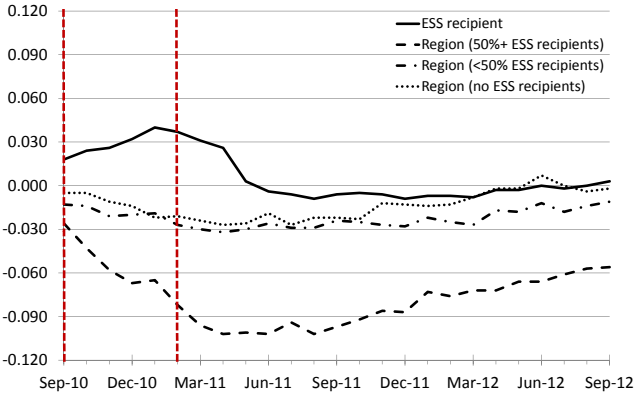
Difference-in-difference estimates of the impact of the earthquakes on various firm-level outcomes using ordinary least squares regression, estimated separately for each post-quake month. The dependent variable is the change in outcome from the pre-quake period to the current month. Solid lines report point estimates of the coefficient on an indicator variable for being located in Greater Christchurch prior to the earthquakes. Dotted lines are 95% confidence intervals (calculated with robust standard errors). Vertical dashed red lines denote the months of the major earthquakes. Auckland/Hamilton firms are reweighted to reflect pre-quake composition of Greater Christchurch firms. Each regression includes controls for initial firm: size, employment growth, age, average wage, profitability, multi-location status, business type, and industry.

Figure 3: Average impact of earthquakes on performance, conditional on survival



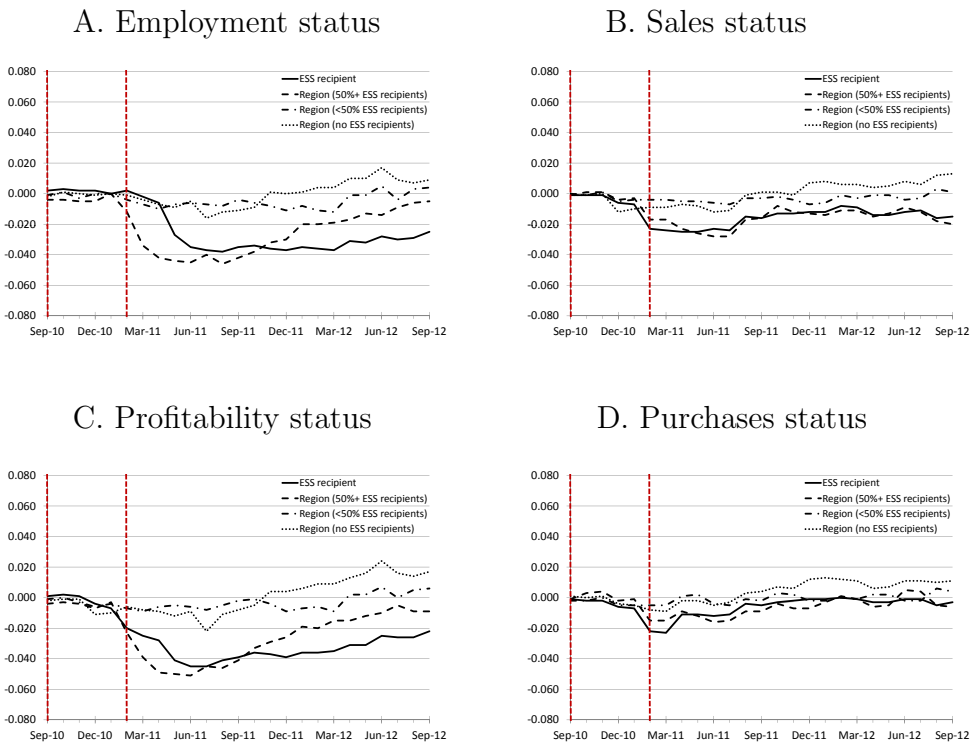
See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month.

Figure 4: Impact of earthquakes on employment status by ESS type without control for survival-based eligibility



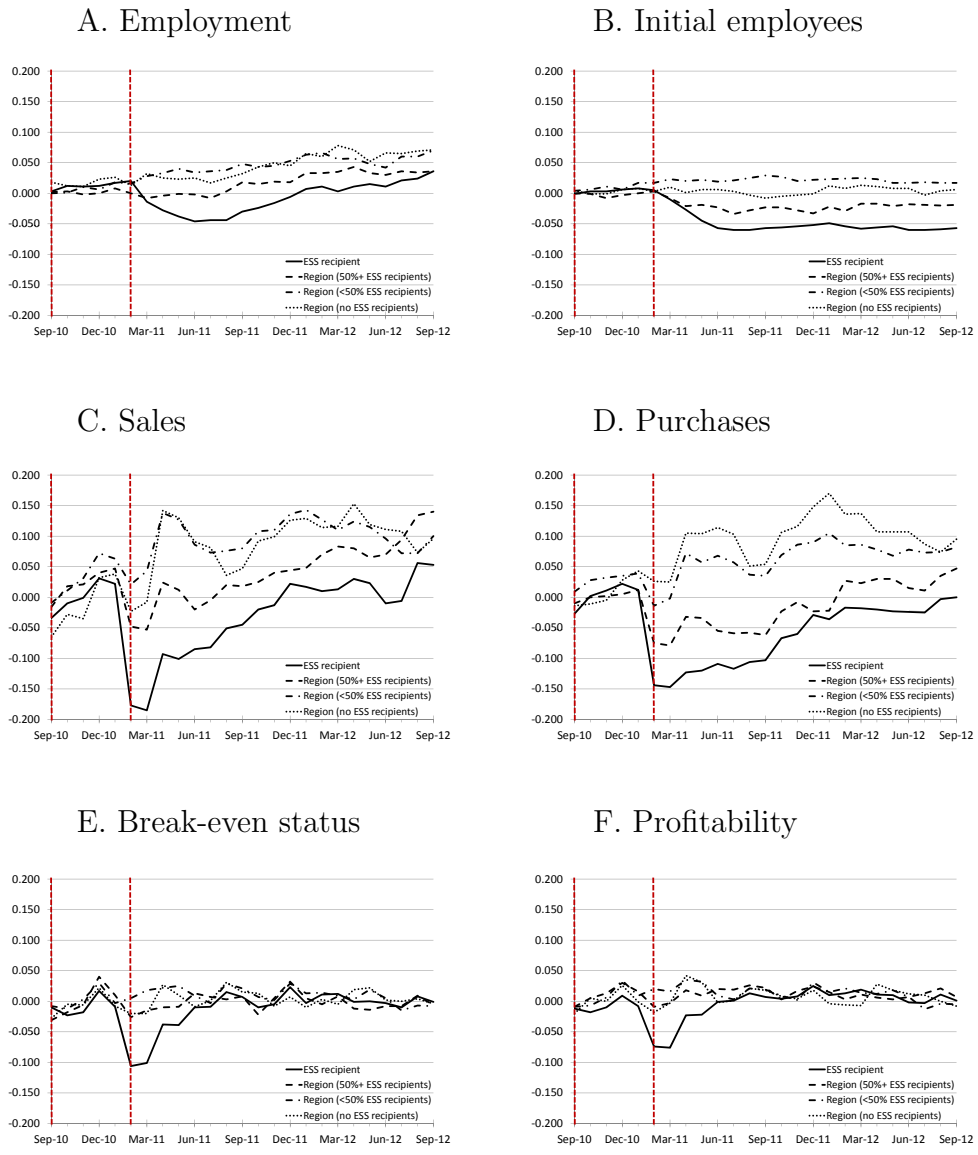
See figure 2 for notes. Regression population is restricted to firms with 50 employees or less at $t = 0$.

Figure 5: Impact of earthquakes on survival by ESS type



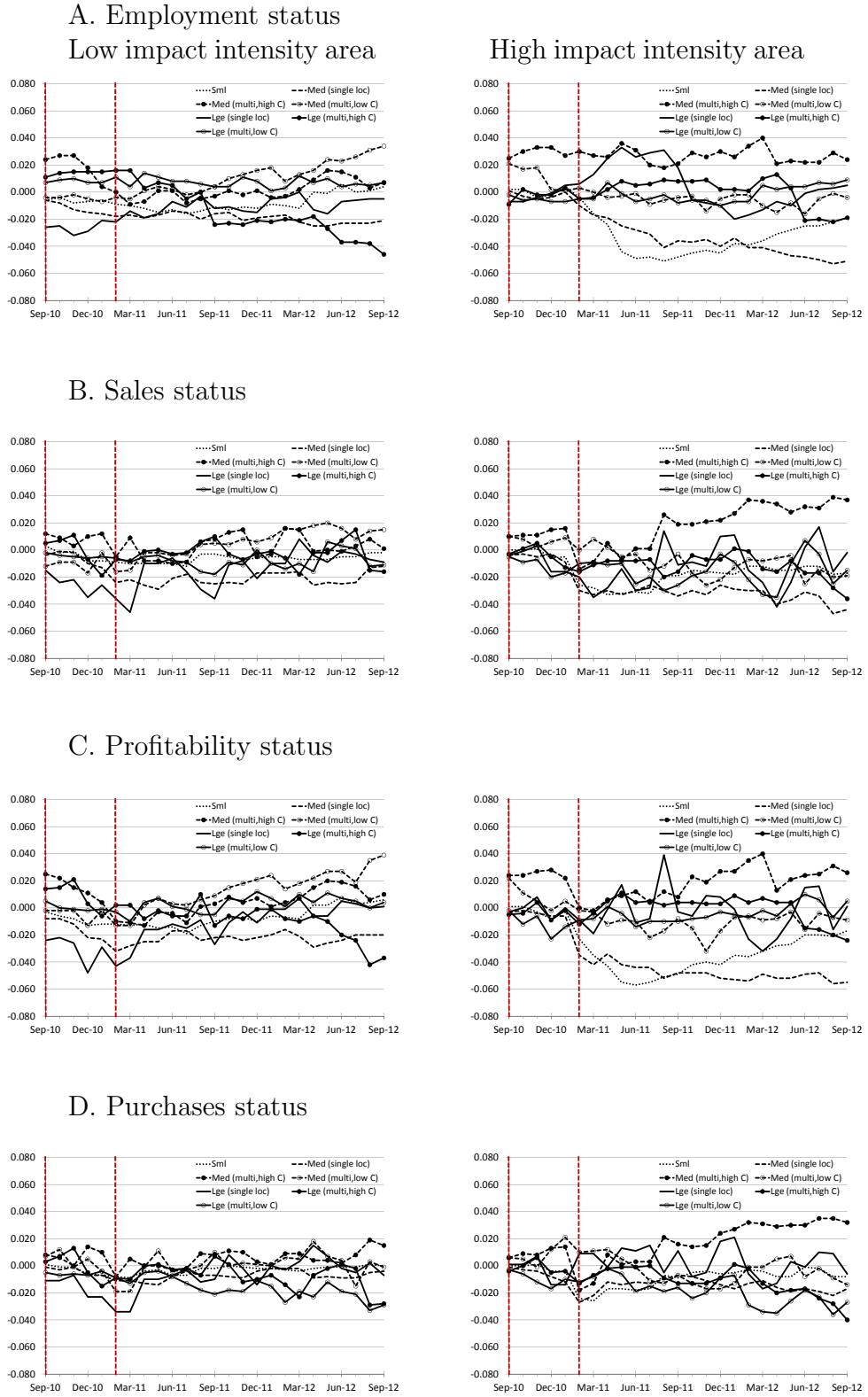
See figure 2 for notes. Regression population is restricted to firms with 50 employees or less at $t = 0$ and which are still employing in January 2011.

Figure 6: Impact of earthquakes on performance by ESS type, conditional on survival



See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month, and which have 50 employees or less at $t = 0$ and are still employing in January 2011.

Figure 7: Impact of earthquakes on survival by firm size and local employment share

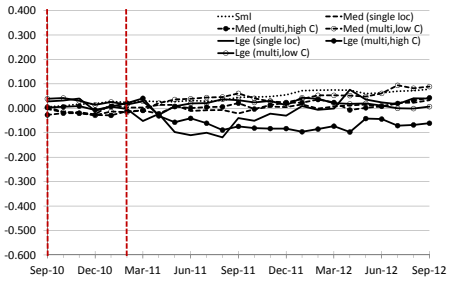


See figure 2 for notes. Firm size categories are small ($L_0 \leq 10$), medium ($10 < L_0 < 50$) and large $L_0 \geq 50$. For multi-location firms, high Greater Christchurch share ("high C") is defined as having at least 20% of employment in the region. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

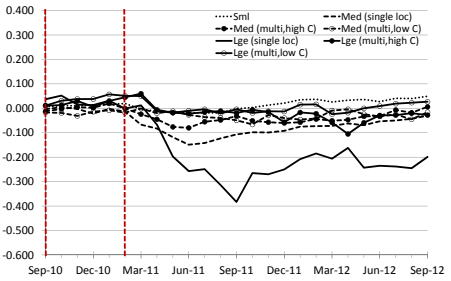
Figure 8: Impact of earthquakes on performance by firm size and local employment share, conditional on survival

A. Employment

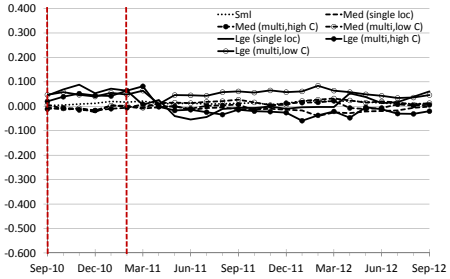
Low impact intensity area

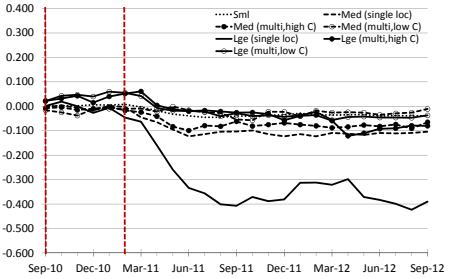


High impact intensity area

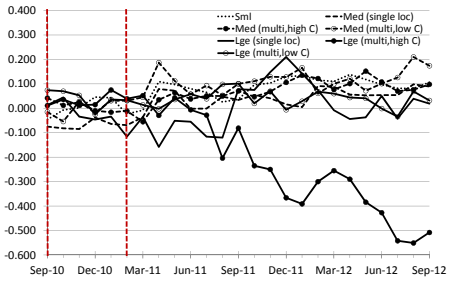


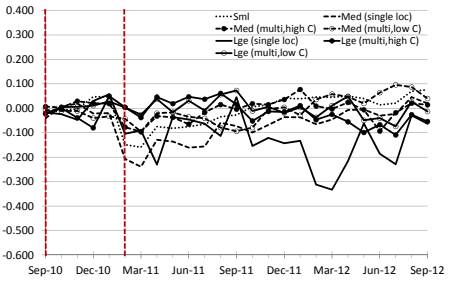
B. Initial employees





C. Sales





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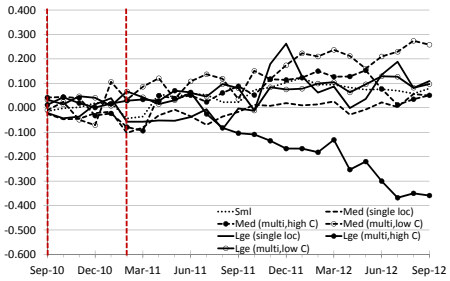
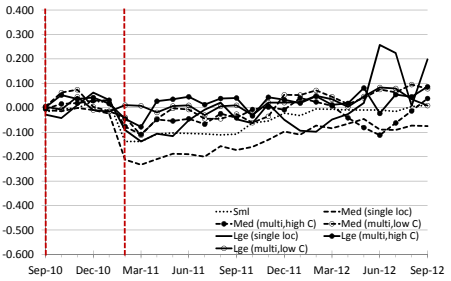
D. Purchases

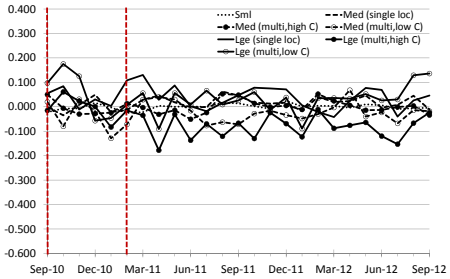
Low impact intensity area

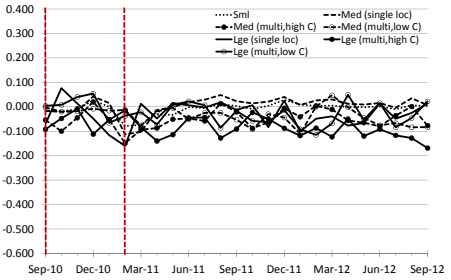


High impact intensity area

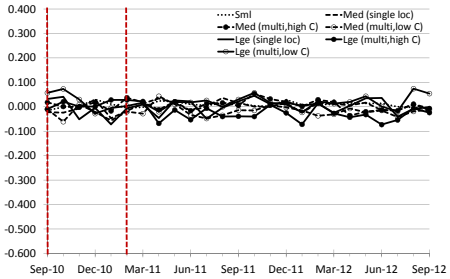


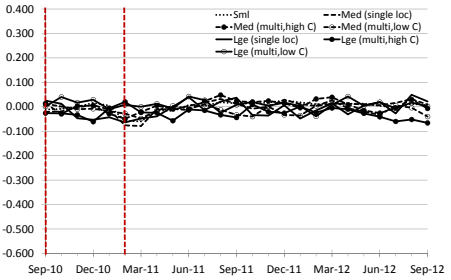
E. Break-even status





F. Profitability



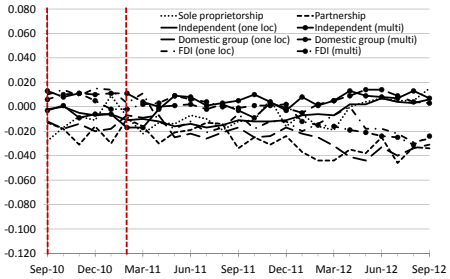


See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month. Firm size categories are small ($L_0 \leq 10$), medium ($10 < L_0 < 50$) and large $L_0 \geq 50$. For multi-location firms, high Greater Christchurch share ("high C") is defined as having at least 20% of employment in the region. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

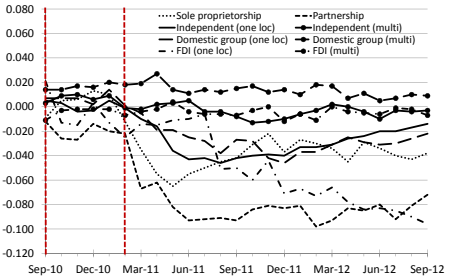
Figure 9: Impact of earthquakes on survival by business type

A. Employment status

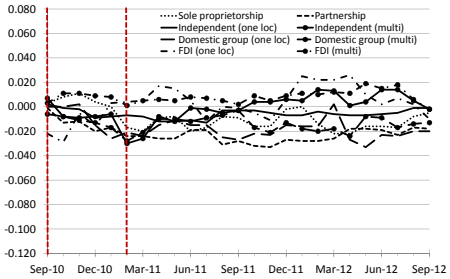
Low impact intensity area

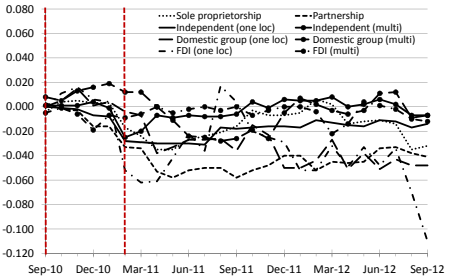


High impact intensity area

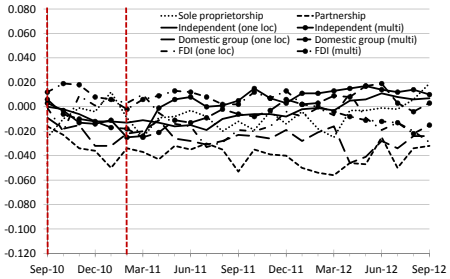


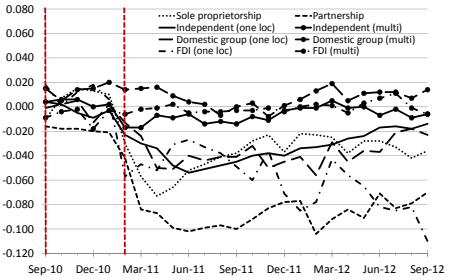
B. Sales status



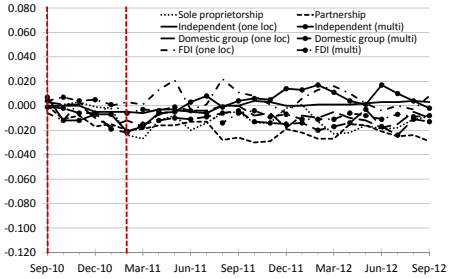


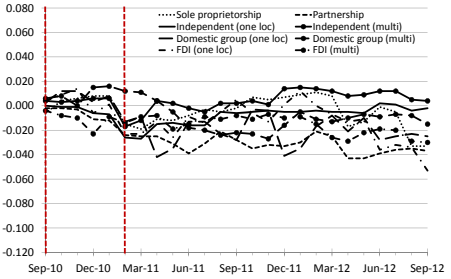
C. Profitability status





D. Purchases status



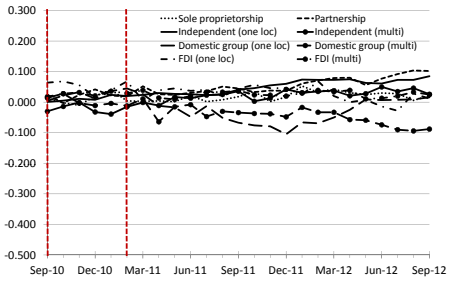


See figure 2 for notes. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

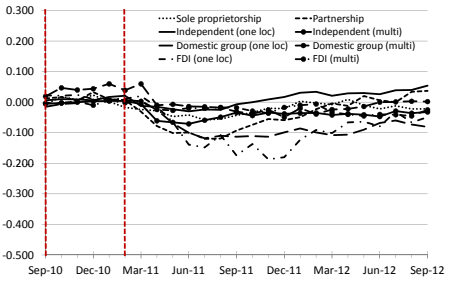
Figure 10: Impact of earthquakes on performance by business type, conditional on survival

A. Employment

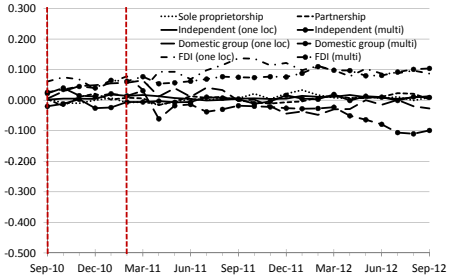
Low impact intensity area

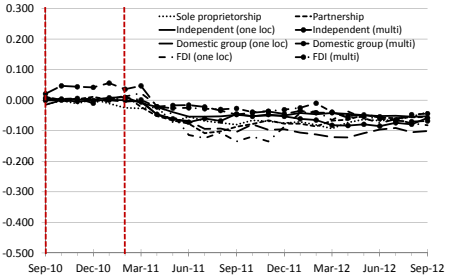


High impact intensity area

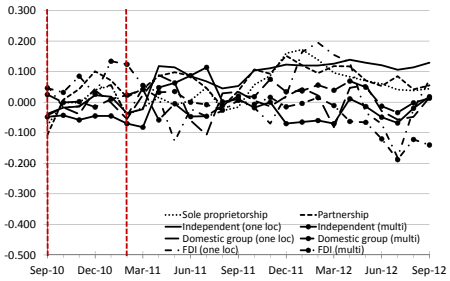


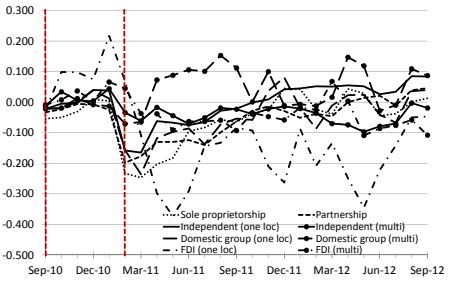
B. Initial employees





C. Sales





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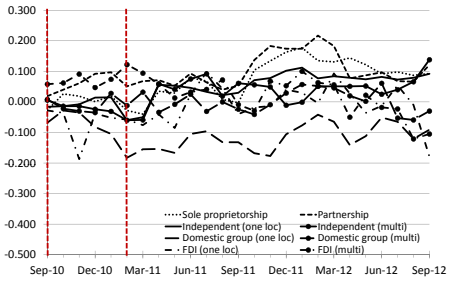
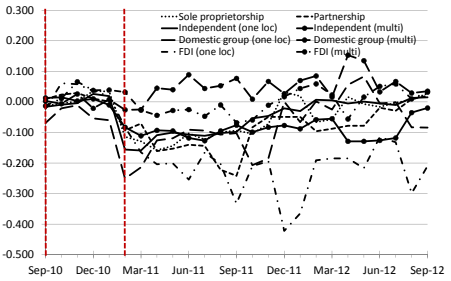
D. Purchases

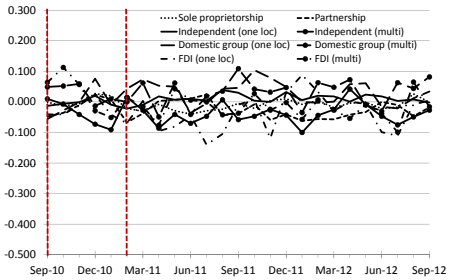
Low impact intensity area

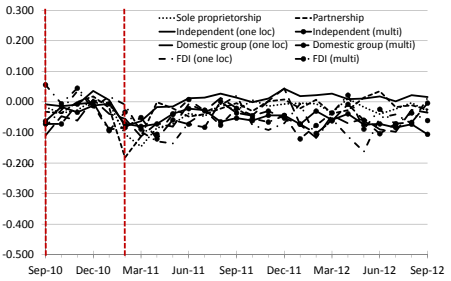


High impact intensity area

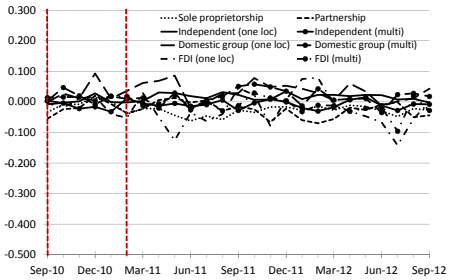


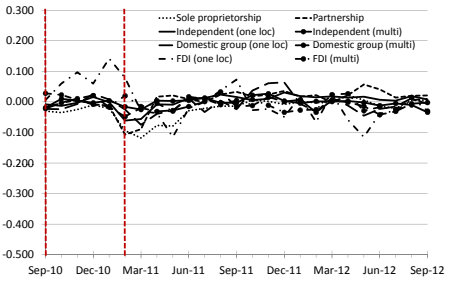
E. Break-even status





F. Profitability



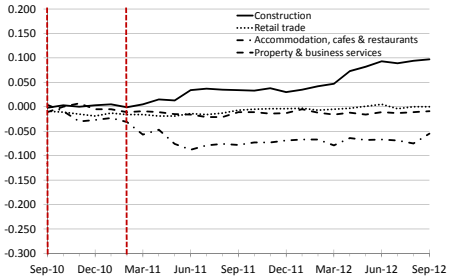


See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

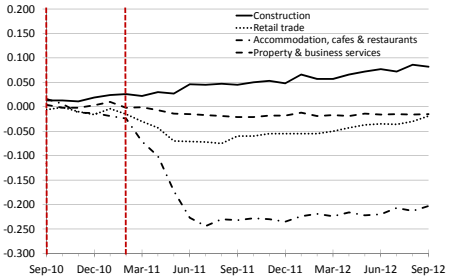
Figure 11: Impact of earthquakes on survival by industry

A. Employment status

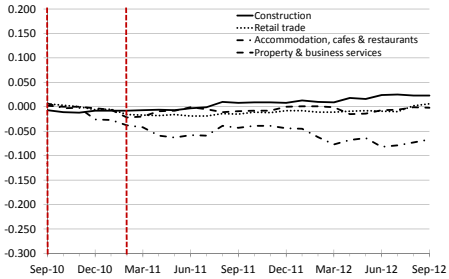
Low impact intensity area

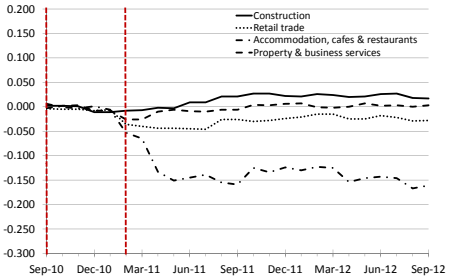


High impact intensity area

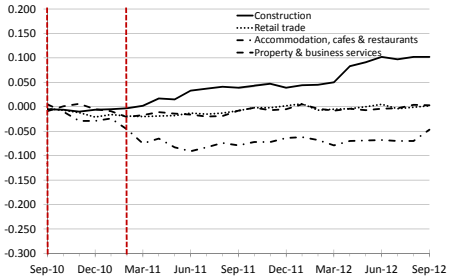


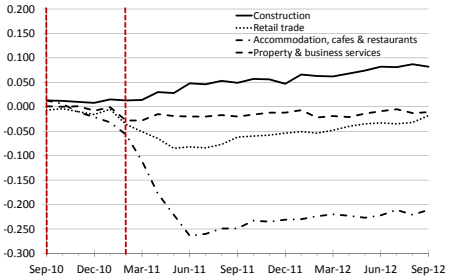
B. Sales status



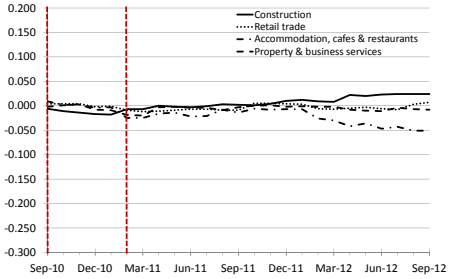


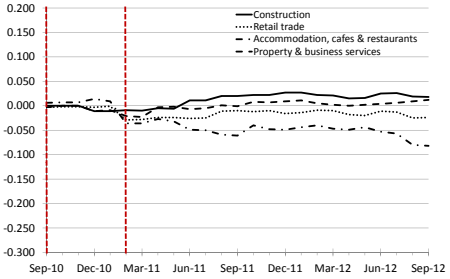
C. Profitability status





D. Purchases status



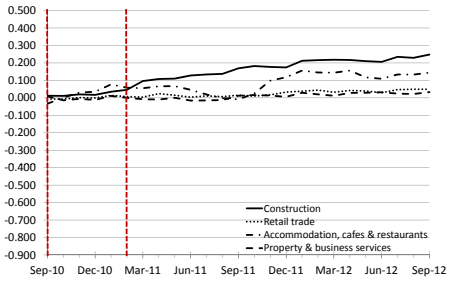


See figure 2 for notes. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

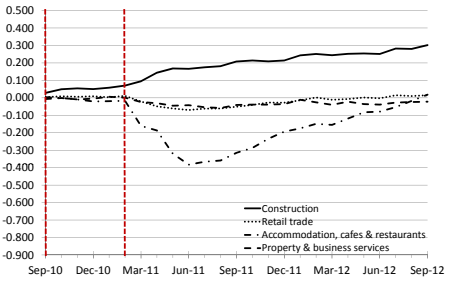
Figure 12: Impact of earthquakes on performance by industry, conditional on survival

A. Employment

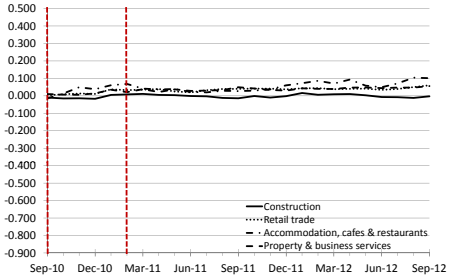
Low impact intensity area

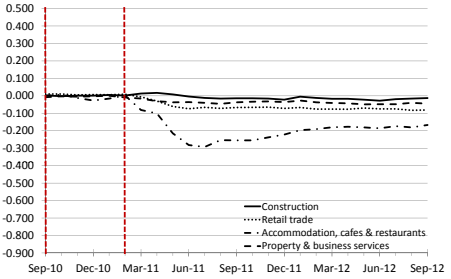


High impact intensity area

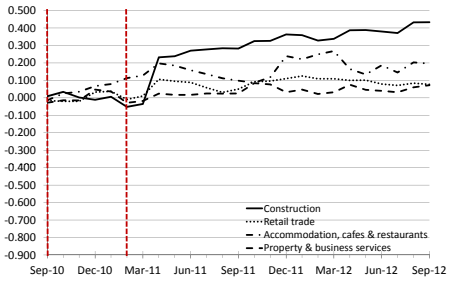


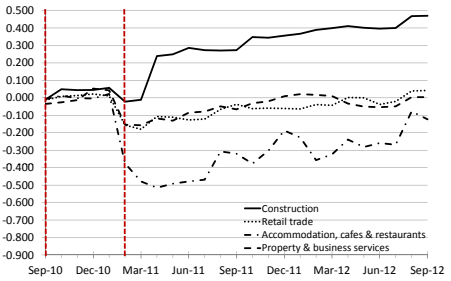
B. Initial employees





C. Sales





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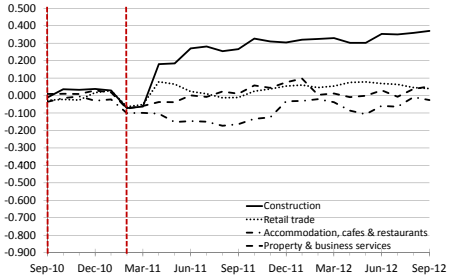
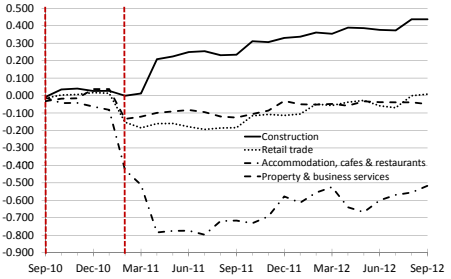
D. Purchases

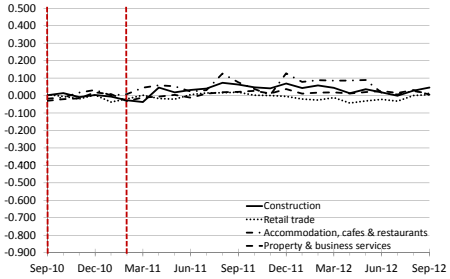
Low impact intensity area

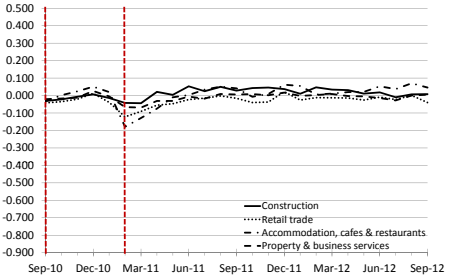


High impact intensity area

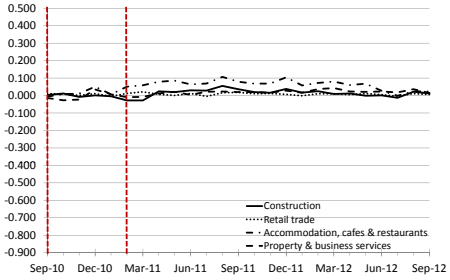


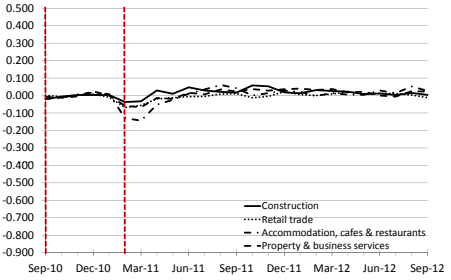
E. Break-even status





F. Profitability



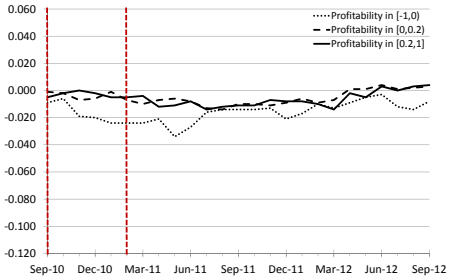


See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

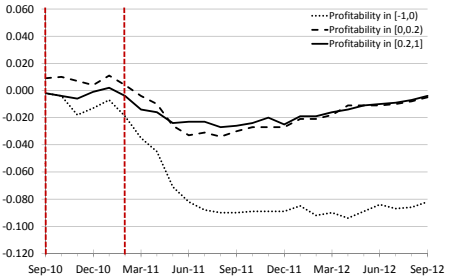
Figure 13: Impact of earthquakes on survival by prior profitability

A. Employment status

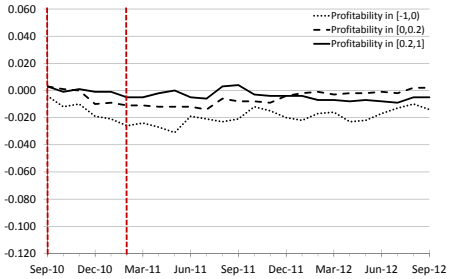
Low impact intensity area

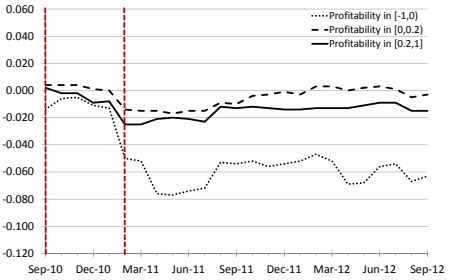


High impact intensity area

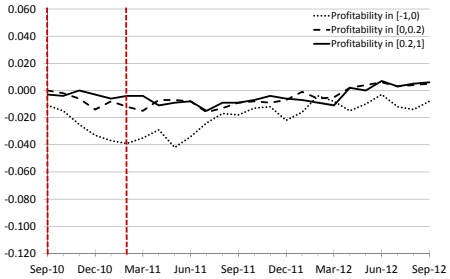


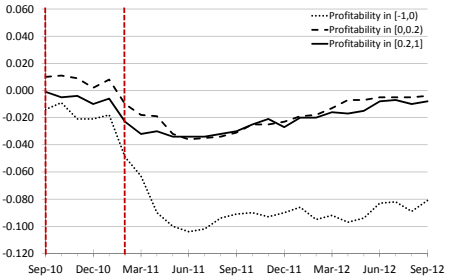
B. Sales status



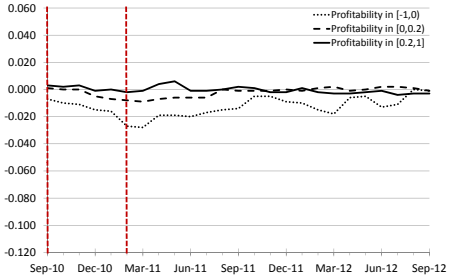


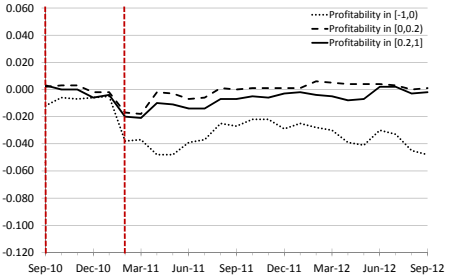
C. Profitability status





D. Purchases status



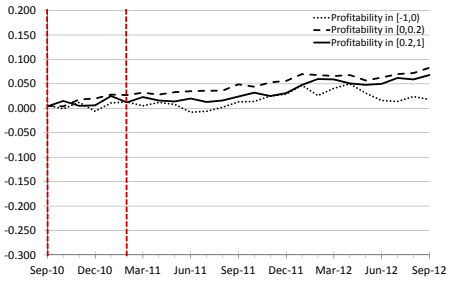


See figure 2 for notes. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations.

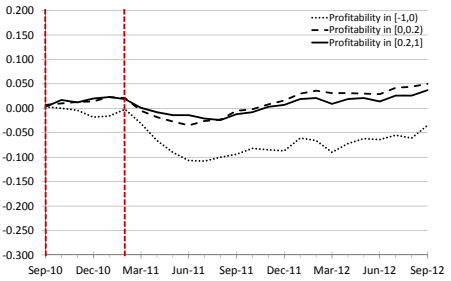
Figure 14: Impact of earthquakes on performance by prior profitability, conditional on survival

A. Employment

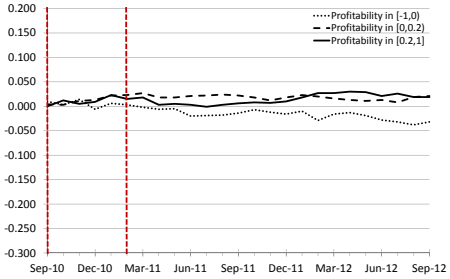
Low impact intensity area

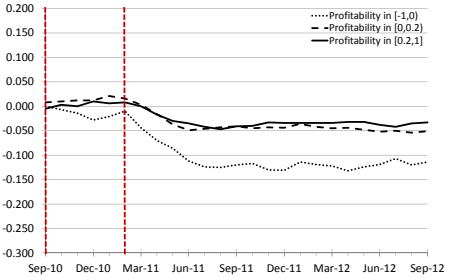


High impact intensity area

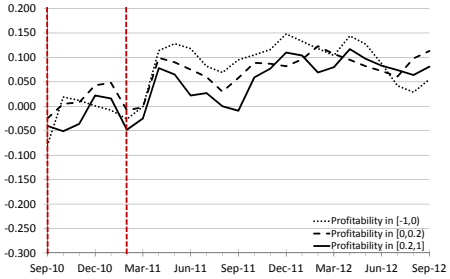


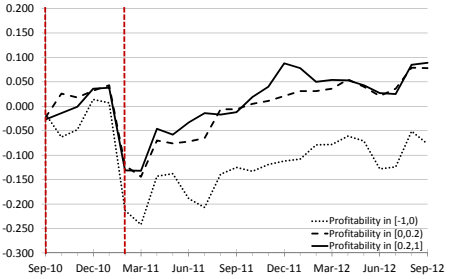
B. Initial employees





C. Sales





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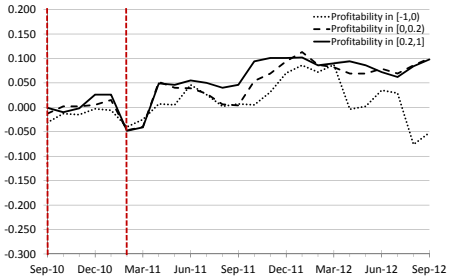
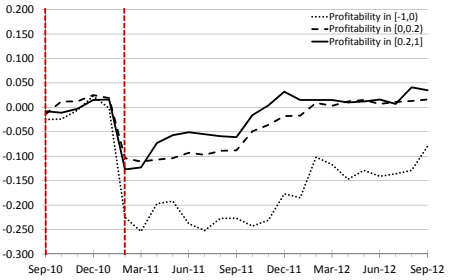
D. Purchases

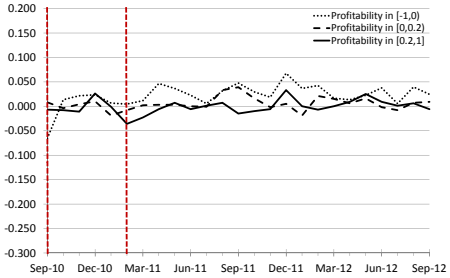
Low impact intensity area

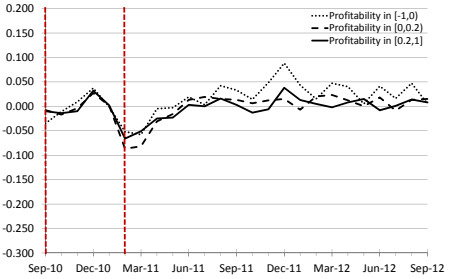


High impact intensity area

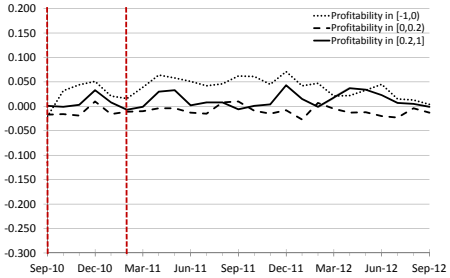


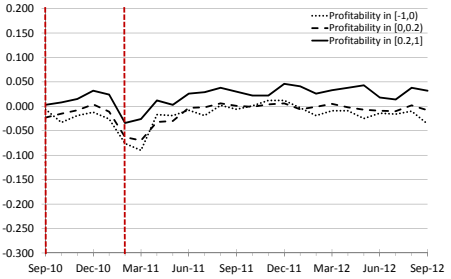
E. Break-even status





F. Profitability





See figure 2 for notes. Regression population is restricted to firms with the relevant outcome variable in each particular month. High impact intensity areas are meshblocks with at least half of eligible firms receiving the ESS. Multi-location firms are assigned based on the maximal value of this share across their meshblock locations. Estimated effect on break-even status is normalised by pre-February 2011 average to aid interpretation.

Appendix A – Detailed industry results

Dependent variable	(1)	(2)	(3)	(4)
Profitability status	Sep-10	Feb-11	Sep-11	Sep-12
Low impact intensity areas				
Agriculture, forestry & fishing	-0.007	-0.011	-0.010	-0.003
	[0.014]	[0.016]	[0.019]	[0.022]
Mining & manufacturing	0.013*	-0.005	-0.009	-0.007
	[0.005]	[0.010]	[0.012]	[0.014]
Construction	-0.005	-0.003	0.039**	0.102**
	[0.008]	[0.013]	[0.014]	[0.015]
Wholesale trade	-0.001	-0.012	-0.034*	-0.047*
	[0.007]	[0.011]	[0.016]	[0.019]
Retail trade	-0.004	-0.019	-0.008	0.002
	[0.007]	[0.011]	[0.013]	[0.015]
Accommodation, cafes & restaurants	0.005	-0.046*	-0.079**	-0.047
	[0.012]	[0.020]	[0.023]	[0.025]
Transport & storage	-0.012	0.015	0.027	0.008
	[0.013]	[0.016]	[0.020]	[0.025]
Communication, finance, insurance,	-0.009	-0.021	-0.008	0.003
property & business services	[0.008]	[0.013]	[0.014]	[0.016]
Education, health, community, cultural,	-0.006	-0.018	-0.029*	-0.025
recreational, personal & other services	[0.007]	[0.011]	[0.013]	[0.015]
High impact intensity areas				
Agriculture, forestry & fishing	-0.007	0.002	-0.058	-0.017
	[0.029]	[0.034]	[0.043]	[0.046]
Mining & manufacturing	0.009	-0.008	-0.011	0.019
	[0.006]	[0.010]	[0.012]	[0.013]
Construction	0.013*	0.013	0.049**	0.082**
	[0.007]	[0.011]	[0.013]	[0.015]
Wholesale trade	0.004	-0.003	-0.003	0.001
	[0.005]	[0.009]	[0.013]	[0.015]
Retail trade	-0.007	-0.036**	-0.062**	-0.018
	[0.006]	[0.010]	[0.011]	[0.012]
Accommodation, cafes & restaurants	0.013	-0.057**	-0.249**	-0.211**
	[0.010]	[0.018]	[0.023]	[0.024]
Transport & storage	-0.006	-0.026	-0.009	0.000
	[0.015]	[0.024]	[0.025]	[0.029]
Communication, finance, insurance,	0.001	-0.028**	-0.020	-0.011
property & business services	[0.005]	[0.009]	[0.010]	[0.012]
Education, health, community, cultural,	-0.008	-0.039**	-0.076**	-0.075**
recreational, personal & other services	[0.007]	[0.012]	[0.015]	[0.016]

Dependent variable	(1)	(2)	(3)	(4)
Employment	Sep-10	Feb-11	Sep-11	Sep-12
Low impact intensity areas				
Agriculture, forestry & fishing	0.054*	0.037	0.058*	0.040
	[0.023]	[0.027]	[0.028]	[0.031]
Mining & manufacturing	-0.012	-0.014	0.011	0.018
	[0.011]	[0.017]	[0.016]	[0.020]
Construction	0.012	0.046**	0.169**	0.248**
	[0.011]	[0.016]	[0.021]	[0.027]
Wholesale trade	0.019	0.039	0.009	-0.017
	[0.017]	[0.039]	[0.019]	[0.023]
Retail trade	-0.007	0.007	0.015	0.049**
	[0.009]	[0.013]	[0.016]	[0.019]
Accommodation, cafes & restaurants	-0.034*	0.058*	-0.009	0.144**
	[0.017]	[0.024]	[0.037]	[0.038]
Transport & storage	-0.012	0.034	0.001	0.036
	[0.018]	[0.022]	[0.029]	[0.038]
Communication, finance, insurance,	0.008	0.000	0.012	0.033
property & business services	[0.010]	[0.014]	[0.018]	[0.023]
Education, health, community, cultural,	0.008	0.002	-0.007	0.040*
recreational, personal & other services	[0.008]	[0.013]	[0.016]	[0.018]
High impact intensity areas				
Agriculture, forestry & fishing	0.038	0.044	0.033	-0.053
	[0.044]	[0.047]	[0.052]	[0.074]
Mining & manufacturing	0.005	-0.003	-0.020	-0.019
	[0.008]	[0.012]	[0.016]	[0.020]
Construction	0.028**	0.070**	0.208**	0.302**
	[0.010]	[0.014]	[0.020]	[0.024]
Wholesale trade	0.007	0.038	-0.006	-0.006
	[0.017]	[0.037]	[0.017]	[0.022]
Retail trade	0.004	0.011	-0.051**	0.015
	[0.007]	[0.010]	[0.015]	[0.016]
Accommodation, cafes & restaurants	0.004	-0.017	-0.315**	0.018
	[0.014]	[0.021]	[0.054]	[0.049]
Transport & storage	-0.010	-0.001	-0.048	-0.071
	[0.018]	[0.028]	[0.035]	[0.047]
Communication, finance, insurance,	-0.007	0.001	-0.041**	-0.022
property & business services	[0.008]	[0.011]	[0.014]	[0.018]
Education, health, community, cultural,	-0.014	0.006	-0.089**	-0.033
recreational, personal & other services	[0.009]	[0.013]	[0.018]	[0.021]

Dependent variable **Sales**	(1) Sep-10	(2) Feb-11	(3) Sep-11	(4) Sep-12
Low impact intensity areas				
Agriculture, forestry & fishing	-0.215**	0.098	-0.038	-0.049
	[0.057]	[0.052]	[0.060]	[0.057]
Mining & manufacturing	-0.015	-0.077**	-0.034	0.007
	[0.017]	[0.028]	[0.034]	[0.039]
Construction	0.009	-0.052	0.282**	0.433**
	[0.020]	[0.035]	[0.040]	[0.043]
Wholesale trade	-0.031	-0.092**	-0.095*	-0.022
	[0.024]	[0.034]	[0.040]	[0.046]
Retail trade	-0.016	-0.009	0.050	0.077*
	[0.018]	[0.030]	[0.034]	[0.037]
Accommodation, cafes & restaurants	-0.014	0.113*	0.098	0.196**
	[0.029]	[0.045]	[0.067]	[0.061]
Transport & storage	-0.021	0.098*	0.046	-0.019
	[0.032]	[0.046]	[0.061]	[0.081]
Communication, finance, insurance,	-0.028	-0.029	0.025	0.072
property & business services	[0.025]	[0.031]	[0.036]	[0.043]
Education, health, community, cultural,	-0.058**	-0.121**	-0.011	0.029
recreational, personal & other services	[0.020]	[0.032]	[0.028]	[0.032]
High impact intensity areas				
Agriculture, forestry & fishing	0.049	0.137	0.134	0.074
	[0.074]	[0.104]	[0.096]	[0.103]
Mining & manufacturing	-0.041**	-0.182**	-0.026	0.083**
	[0.015]	[0.026]	[0.026]	[0.030]
Construction	-0.010	-0.022	0.273**	0.470**
	[0.018]	[0.029]	[0.031]	[0.038]
Wholesale trade	-0.009	-0.063**	-0.036	-0.037
	[0.020]	[0.024]	[0.029]	[0.048]
Retail trade	-0.013	-0.156**	-0.037	0.042
	[0.010]	[0.022]	[0.029]	[0.031]
Accommodation, cafes & restaurants	-0.007	-0.376**	-0.320**	-0.123
	[0.021]	[0.053]	[0.085]	[0.082]
Transport & storage	-0.004	-0.024	-0.105	-0.147
	[0.036]	[0.055]	[0.075]	[0.084]
Communication, finance, insurance,	-0.035*	-0.154**	-0.066*	0.004
property & business services	[0.015]	[0.023]	[0.028]	[0.033]
Education, health, community, cultural,	-0.021	-0.189**	-0.105**	-0.063
recreational, personal & other services	[0.019]	[0.031]	[0.040]	[0.039]

Dependent variable	(1)	(2)	(3)	(4)
Profitability	Sep-10	Feb-11	Sep-11	Sep-12
Low impact intensity areas				
Agriculture, forestry & fishing	-0.088**	0.012	-0.009	-0.081**
	[0.028]	[0.028]	[0.028]	[0.030]
Mining & manufacturing	0.002	-0.034*	0.000	-0.005
	[0.013]	[0.015]	[0.014]	[0.015]
Construction	0.003	-0.028	0.036**	0.012
	[0.013]	[0.014]	[0.012]	[0.014]
Wholesale trade	-0.001	-0.004	-0.001	-0.009
	[0.017]	[0.018]	[0.019]	[0.019]
Retail trade	0.011	0.012	0.018	0.006
	[0.009]	[0.010]	[0.010]	[0.010]
Accommodation, cafes & restaurants	-0.006	0.051**	0.079**	0.023
	[0.015]	[0.018]	[0.018]	[0.020]
Transport & storage	-0.023	0.014	-0.029	-0.010
	[0.023]	[0.022]	[0.025]	[0.027]
Communication, finance, insurance,	-0.014	-0.009	0.020	0.015
property & business services	[0.014]	[0.016]	[0.015]	[0.017]
Education, health, community, cultural,	-0.014	-0.011	-0.001	-0.019
recreational, personal & other services	[0.011]	[0.014]	[0.013]	[0.013]
High impact intensity areas				
Agriculture, forestry & fishing	-0.038	0.037	-0.008	-0.032
	[0.052]	[0.052]	[0.058]	[0.059]
Mining & manufacturing	-0.035**	-0.072**	-0.032*	-0.007
	[0.012]	[0.014]	[0.013]	[0.013]
Construction	-0.021	-0.037**	0.017	0.004
	[0.012]	[0.013]	[0.013]	[0.013]
Wholesale trade	0.022	0.000	0.014	0.011
	[0.014]	[0.016]	[0.017]	[0.015]
Retail trade	0.001	-0.068**	0.011	-0.012
	[0.007]	[0.010]	[0.009]	[0.009]
Accommodation, cafes & restaurants	-0.018	-0.129**	0.042	0.027
	[0.013]	[0.020]	[0.025]	[0.019]
Transport & storage	0.001	0.000	-0.014	0.020
	[0.025]	[0.028]	[0.026]	[0.025]
Communication, finance, insurance,	-0.007	-0.059**	0.023*	0.023*
property & business services	[0.010]	[0.013]	[0.011]	[0.012]
Education, health, community, cultural,	-0.002	-0.057**	0.026	-0.004
recreational, personal & other services	[0.012]	[0.014]	[0.014]	[0.014]

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