Factors influencing impacts on and recovery trends of organisations: evidence from the 2010/2011 Canterbury earthquakes

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Highlights

- The most disruptive impact for organisations in Canterbury was Customer Issues
- Organisation age and size were not predictors of impact or recovery
- Sector was a predictor of both impact and recovery for organisations
- Organisations that rented recovered better than those that only owned premises
- Recovery trends differed noticeably when initial impacts were taken into account

Abstract

In 2010 and 2011, the Canterbury region of New Zealand was struck by a series of earthquakes, the most serious of which was a magnitude M=6.3 earthquake on the 22nd of February 2011 centered near the heart of Christchurch city. This earthquake led to the cordoning of the central business district due to safety concerns, with parts of the city remaining closed to the public for more than two years following the earthquakes. With large numbers of organisations needing to relocate and being faced with ongoing infrastructure disruption, and significant concerns for staff welfare, the February 2011 Canterbury earthquake provides a valuable case study for enhancing the understanding of how businesses are affected by and recover from disasters**.** In this paper, using data from over 540 organisations affected by the Canterbury earthquakes, we reassess some of the main findings from the international literature about how organisational demographics, including age, size, sector and property ownership, influence organisations' level of disruption from disaster-induced impacts, and how the same attributes might influence organisations' ability to recover following a significant disaster. The paper finds that human / organisational issues, in particular 'Customer Issues' impacts were most disruptive for

organisations. Furthermore, this paper finds that, contrary to much current literature, organisational age and size do not strongly predict disaster impact and recovery success. Sector was found to be a predictor of both impact and recovery. Organisations that rented recovered more effectively than those that owned their properties.

Keywords: Organizational Resilience, Disaster recovery, Disaster impact

1   Introduction

At 12:51pm on 22 February 2011, the city of Christchurch in New Zealand was shaken by a shallow Mw 6.3 earthquake centered approximately 10 km south-east of the Central Business District (CBD), at a depth of only 5 km. The earthquake generated peak ground accelerations in the Christchurch CBD that were, on average, 0.5g in both the horizontal and vertical direction [1], 50 percent greater than the design loadings for new buildings in Christchurch. The February 2011 earthquake caused significant liquefaction in areas throughout the Christchurch's southern and eastern suburbs [2]. The combined effects of ground shaking and liquefaction had significant impacts on people, buildings, and infrastructure in Christchurch and across the Canterbury region [3][4]. This event came at a time when the region's businesses were still struggling to recover from the Mw 7.1 earthquake, which hit Canterbury on September, 2010 with an epicentre located 40 km west of Christchurch [5]. When the February 2011 earthquake struck, organisations in the region had been pursuing their recovery from the September 2010 event for nearly five months.

For many organisations, the February 2011 earthquake effectively reset the clock on their recovery timeline; in many cases causing impacts far beyond what was seen following the September 2010 earthquake. Many organisations applied lessons learned from the September event and proactively found avenues for business continuity immediately following the February 2011 earthquake. Others started questioning the long-term viability of their organisation in the new post-earthquake landscape.

The Christchurch CBD and surrounding areas were significantly and repeatedly disrupted throughout 2010 and 2011, and businesses needed to continuously adjust to a changing economic and operational environment. As a result, the Canterbury earthquakes provide a valuable case study for enhancing the understanding of how businesses are affected by and recover from disasters.

Several large and influential quantitative assessments of post-disaster business recovery were conducted in the 1990s and early 2000s. The findings from those assessments form the basis of the current understanding on how businesses are affected by and recover from disasters. In this paper, using data from over 540 organisations affected by the February 2011 Christchurch earthquake, we reassess and calibrate some of those findings. In particular the paper aims to test the following hypotheses:

1a. Some disaster impacts are more disruptive than others.

1b. Organisations that are more heavily impacted by disasters recover less effectively.

2a. Smaller businesses suffer more severe disruptions from disasters than larger businesses.

2b. Smaller businesses are less likely to recover than larger businesses.

3a Younger organisations suffer more severe disruptions from disasters than older businesses.

3b. Younger businesses are likely to recover less effectively than older businesses.

4a. The severity of organisation disruption from disasters is sector-specific.

4b. The effectiveness of organisation recovery following disasters is sector-specific.

5a. Those that rent their business premises suffer more severe disruptions than those that own their business properties

5b. Those that rent their business premises recover less effectively than those that own their business properties

The paper is structured as follows: Section 2 presents an overview of the international literature findings that form the basis of the above-mentioned hypothesis. Section 3 presents the data collection methodology and the methods used to test the above-mentioned hypotheses. Section 4 presents the findings from the data analysis. Finally, the paper concludes, in Section 5, by discussing the findings and recommending future research.

2   Organisation Impact, Recovery and Resilience from Disaster: literature review

A number of studies have sought to understand the factors that influence the way disasters impact organisations and the organisational factors that influence how they are affected by and recover from disasters. Through these analyses, researchers have found that organisations are impacted by a variety of mechanisms [6]. Organisations are forced to close, relocate, or experience decreased productivity as a result of direct physical damage to their buildings, assets, and inventory [7][8][9]. They can also experience significant work stoppage and reduced productivity as a result of infrastructure disruptions, including, electricity, water, sewage services, fuel, transportation, and telecommunications [9][10][11].

In addition to disruptions caused by direct physical damage, indirect or secondary effects can negatively impact organisations as a result of disruptions to their labour supply (staff members), customers, suppliers, and neighbourhoods [4][12][13]. Organisations' current and future labour supply may suffer dislocation as a result of a disaster, and experience reduced productivity associated with disaster-induced strain [6][14][15][16]. Population dislocation and demographic change can also have negative effects on organisations' customer-base [15][16][17][18]. Customers may also have changed demands or spending habits after disasters, which can disrupt organisations [6][19][20]. At the same time, disruptions to suppliers can also negatively impact organisations [15][21][22]. Finally, disruptions to the neighbourhoods in which organisations are situated, such as damage to surrounding buildings and changed perceptions of the safety of an area, can have negative impacts on organisations even if their building is unaffected [17][23][24][25][26].

The direct and indirect effects an organisation experiences after a disaster influences the probability that it will recover [27]. Organisations that experience greater property damage or that experience capacity reductions from indirect impact are more likely to fail long-term [6][8][9][19][28].

Studies investigating the ways disasters affect organisations, have also identified a number of organisational characteristics that influence an organisation's vulnerability or sensitivity to disruption, and their capacity to recover (i.e. to regain a level of performance that allows the organisation to achieve its core objectives and be financial sustainable). Although studies have identified a number of characteristics from market reach [29] to social connectivity [30], this paper focuses on four organisational characteristics that are commonly associated with organisations' post disaster outcomes. These are organisational size, age, industry sector, and property ownership.

First, organisation size (the number of full-time employees) is consistently associated with vulnerability and recovery. Small to medium size enterprises (SMEs) tend to experience higher rates of failure following disasters than larger organisations following disasters [17][31]. They tend to have fewer financial resources, less access to capital, and higher rates of failure than large enterprises, during business as usual, which makes them more vulnerable to disaster disruption [6][10][19]. Compared to their larger counterparts, small firms are more likely to depend primarily on local customers, lack the financial resources needed for recovery, and have less access to governmental recovery programs [19][32]. Additionally, studies have found that larger organisations were more likely to engage in pre-disaster planning which may have a positive relationship to organisational recovery [33][34].

The second characteristic, organisation age is closely associated with organisation size. Smaller organisations also tend to be younger. However, the relationship between organisation age and post-disaster impact and recovery is less clear [15][35]. For example, Webb et al. [29] did not find a significant relationship between age and recovery in their analysis of organisations following the Loma Prieta earthquake in 1989, but it was significant for organisations following Hurricane Andrew in 1992. Age has also been shown to have a complicated relationship with organisational preparedness. Dahlhamer and Souza [36] and Howe [37] found that younger organisations were less likely to engage in formal preparedness measures, whereas Quarantelli et al. [34] found that older enterprises took fewer precautionary measures.

Third, organisational industry sector is a frequently assessed characteristic which influences post-disaster outcomes in a number of ways. Wholesale and retail businesses generally report experiencing significant sales losses, relatively high rates of failure, and slower rates of recovery [10][17][38]. Kroll et al. [10] also found that trades such as finance and real estate following the Loma Prieta earthquake experienced proportionally greater losses and had more difficulty recovering than other types of organisations. Conversely, large disasters have been shown to stimulate activity and growth for organisations involved in the manufacturing and construction sectors [29][39][40]. However, the relationship between industry sector and recovery is not consistent across all disasters or throughout the recovery period. Dahlhamer and Tierney [41] did not find the type of sector to be a statistically significant predictor of short-term business recovery in Santa Cruz after the Loma Prieta earthquake or in South Dade after Hurricane Andrew. However, industry sector *was* found to be a strong predictor of long-term recovery in South Dade but not in Santa Cruz [29].

Finally, previous studies also indicate that whether or not organisations own the building from which they operate can influence their recovery outcomes. Dahlhamer and Tierney [41] argued that building ownership may be a partial proxy for pre-disaster financial success, and that owners have more control over building enhancements that can mitigate the effects of a disaster on their organisation. Durkin [42] suggests owning a building may increase the chance of business survival following a disaster.

Chang and Falit-Biamonte [23] found that renters were more likely to experience significant financial losses than organisations that owned their building. Interestingly, Tierney [43] found that organisations that rented their premises were also likely to be smaller and in sectors that are often associated with high rates of post-disaster failure (particularly those in wholesale and retail trade, services, and real estate).

The existing research provides a useful theoretical baseline for the examination presented in this paper. However, a majority of these commonly cited studies were conducted in the United States, and are now several decades old. Additionally, depending on where and when these studies were conducted different relationships emerged. Therefore, it is useful to empirically reassess the relationships between organisational characteristics and disaster impact and recovery in the context of the earthquakes in Canterbury, New Zealand.

3   Research Design

3.1   Survey purpose and context

The research presented in this paper is based on data from a survey about business behaviours, resilience and recovery following the 2010/2011 Canterbury earthquakes that was undertaken by Resilient Organisations. It is part of a wider project called the Economics of Resilient Infrastructure, which is aimed at quantifying the economic implications of vulnerabilities to infrastructure.

3.2   Sample description

The survey sample was selected based on two organisational criteria. First, organisations needed to have premises in one of the three districts in the Canterbury region that suffered the majority of direct damage from the 2010/2011 earthquakes: Christchurch City, Selwyn, and Waimakariri districts. Second, the organisations were selected based on their industry sector. In this research, 19 unique sector classifications were used based on categories defined by Australian and New Zealand Standard Industrial Classification (ANZSIC). These sectors (listed in Table 2) cover the vast majority of organisations operating in Canterbury as discussed in Section 3.4.

The database of organisations used in this research, was obtained from a business to business marketing company. The database was divided by sector and included organisation names and contact information.

Organisations were initially contacted by telephone. The respondents could then choose to complete the survey over the telephone, online using a cloud based survey engine, or on a hardcopy. If a response was not received within two weeks, the organisation received a follow up call as a reminder. After two more weeks they received another follow-up call or email.

The survey was open between July 2013 and December 2013. In total 2176 unique organisations were asked to participate, and 541 valid and complete surveys were received, for a response rate of approximately 25%. A valid response was considered as one where at least 40 out of 49 questions were answered.

3.3   Survey questions and data processing

3.3.1 Overview of survey questions

The survey comprised of 11 sections and 49 questions. The questions were a mix of open-ended, closed, check-box and Likert type questions. The survey sections and question topics are summarised in Table 1. Specific questions, relevant to this paper, and the approach adopted for their analysis are described in the following sections.

Table 1   Economics of Resilient Infrastructure 2013 Organisational Resilience and Recovery Survey

Section title	Question topics
About you	Respondent and organisation name and contact details
Your organisation	Organisation age, number of employees, sector, Maori-focus and ownership type
Earthquake impacts	Impacts, mitigation measures, critical infrastructure disruption and closure
Your location	Number of locations, property ownership and property relocation
Your suppliers	Supplier impacts and locations
Your customers	Service delivery and demand changes
Your staff	Staffing changes and challenges
Insurance	Recovery financing, insurance coverage and satisfaction
Organisational changes	Collaborations, business model and cost changes
Recovery	Recovery progress and situation
Resilience	Resilience profile using Resilient Organisations 13 resilience indicators thumbprint [44][45] critical infrastructure dependency, emergency planning, current cashflow and profitability

3.3.2 Organisation demographics

Much of the literature identifies various organisational demographics as pre-determining factors of organisational resilience or effective disaster recovery. To enable an analysis of how recovery is affected by organisational demographics, a number of demographic questions were asked. The questions relevant to this paper are shown in Table 2.

Table 2   Organisational demographic survey questions

Demographic	Question	Response Options
Age of Organisation	How many years has your organisation been operating? (in years)	free text field
	Please estimate the number of employees now working in your	free text field

Size of Organisation	organisation (including yourself if you are owner / operator)? Number of full time employees in Canterbury Number of part time employees in Canterbury	
	How many sites or locations does your organisation currently operate from? Within Canterbury: Elsewhere in New Zealand: Outside New Zealand:	free text field
Sector	Please indicate which of the following industry categories best describes your organisation.	• Health Care and Social Assistance; • Professional, Scientific and Technical Services; • Education and Training; • Manufacturing; • Transport, Postal and Warehousing; • Construction; • Retail Trade; • Agriculture, Forestry and Fishing; • Accommodation and Food Services; • Wholesale Trade; • Information Media and Telecommunications; • Electricity, Gas, Water and Waste Services; • Financial and Insurance Services; • Rental, Hiring and Real Estate Services; • Administrative and Support Services; • Public Administration and Safety; • Arts and Recreation Services; • Mining; • Other (please specify)
Property ownership	Does your organisation own or rent the properties from which it is operated? (please tick all that apply)	Own; Rent/Lease

3.3.3 Impact metrics

The organisations surveyed were asked to indicate the level of disruption they experienced in the first three months following the February 2011 earthquake due to 13 different factors, summarised in Table 3. Organisations were asked to rate the disruption on a 4 point scale from very disruptive to not disruptive. For this analysis, the responses were scored evenly along a normal scale (0-1). The impacts were analysed in two separate ways. First the individual impacts were analysed (using a mean and standard deviation analysis) to determine which factor caused the most disruption (Disruption Index (DI), see Section 4.1). Second, an Impact Index (II) was derived to give an overall score for how impacted an organisation was by the earthquakes. This was calculated for each organisation based on an equally weighted average across all of the factors. N/A and missing responses were excluded from the analysis.

Table 3   Impact questions

Question	Response options (in order from most disruptive (1) to least disruptive (0))

In the first three months following the 22 February 2011 earthquake, please indicate how disruptive the following factors were:
  o Difficulty Accessing IT Data.
  o Structural Damage to building Structural damage to building(s) (integrity of building compromised)
  o Non-Structural damage to building (fittings damaged e.g. windows or light fixtures)
  o Machinery loss or damage
  o Office equipment or damage
  o Damage to inventory or stock
  o Damage to ground surface
  o Damage to or closure of adjacent (next door) organisations or buildings
  o Damage to local neighbourhood (e.g. other buildings in area, damage to pavements, etc)
  o Difficulty accessing premises/site
  o Health and safety issues for employees'
  o Supplier issues
  o Customer issues
  o Availability of staff
  o Perceptions of building safety
  o Changes in staff emotional wellbeing
  o Other (please specify)
	Very disruptive;
	Moderately disruptive;
	Slightly disruptive;
	Not disruptive;
	N/A (excluded)

3.3.4 Recovery metrics

Organisations were asked about their recovery status at the time of the survey. Six different questions were used, as summarised in Table 4. These six questions were used to calculate a 'Recovery Index' (RI) as a measure of the recovery situation at the time of the survey. For each question the responses were scored evenly along a normal scale (0-1). Then the average of the six indices, equally weighted, was calculated to give the Recovery Index. N/A and missing responses were excluded from the analysis. As seen in Table 4, these 6 recovery questions cover a number of perspectives of recovery, including reasonably objective financial and more subjective situation self-assessments. An average across these six indices provides a reasonable proxy of recovery suitable for the relative assessments carried out in this paper.

Table 4   Recovery measures

		Question text	Response options (in order from best (1) to worst (0))
1	**Current Situation**	With the earthquakes in mind, is your organisation	Significantly better off; Slightly better off; The same; Slightly worse off; Significantly worse off.

2	**Current productivity**	With the earthquakes in mind, how would you describe your organisation's current productivity?	Greatly increased; Slightly increased; The same; Slightly decreased; Greatly decreased.
3	**State of recovery**	Which of the following statement best describes your organisation at the present time	The event never impacted our organisation; The event was positive for our organisation; We have fully recovered from the earthquakes; We are still recovering from the earthquakes; We are still in survival mode following the earthquakes; We are no longer trading.
4	**Current Cashflow**	How would you rate your organisation's current cashflow?	Excellent; Good; Satisfactory; Poor; Very poor; Don't know (excluded)
5	**Current debt**	How would you describe your organisation's current level of debt?	Minimal/no debt; Moderate debt; High debt; Very high debt; Don't know (excluded)
6a	**Current profitability** (For profit organisations only)	How would you describe your organisation's current profitability?	Highly profitable; Moderately profitable; Breaking even; Unprofitable; Don't know (excluded)
6b	**Current surplus** (Not-for-profit organisations only)	How would you describe your organisation's current financial surplus or deficit?	High surplus; Low surplus; No surplus; Low deficit; High deficit; Don't know (excluded)

For the analysis in this paper, a second measure was devised to describe how well organisations recovered *relative to how heavily they were impacted*. This was called the *Recovery-Impact Index*, RII (Equation 1) and was calculated by averaging the Impact and Recovery Indices as shown below:

$$RII = (II + RI)/2 \qquad\qquad (1)$$

Since the Impact Index (II) is scaled 0 (not disruptive) to 1 (very disruptive) and the Recovery Index (RI) is scaled 0 (poor recovery status) to 1 (good recovery status), the lowest scores on the Recovery-Impact Index relate to those organisations that were not impacted and also reported a low recovery status; whereas the highest RII scores relate to those organisations that were highly impacted and reported a good recovery status.

The RII was developed to enable an assessment of how effectively an organisation has recovered from its initial impacts. This would enable a distinction to be made between those organisations that reported high levels of recovery but were not highly impacted and those that were heavily impacted but still recovered positively. This is, therefore more a measure of the recovery journey (as a transition from impact to the time of survey) rather than just a snapshot of the recovery in time, as RI is. It is believed that this will give a better perspective on how some organisation are more resilient to impacts.

3.4 Survey sample representativeness and limitations

The demographics of the responding organisations were analysed to determine how representative these organisations were of organisations in the Canterbury region. The results of this analysis is summarised in Table 5. Overall, the survey data represented the general population of organisations well, with most sectors and ownership types proportionately well represented. The exceptions were: Rental, Hiring and Real estate and Agriculture, Forestry and Fishing, which were under-represented (13% difference); and Manufacturing which was over-represented (13% difference). Limited liability companies were slightly over-represented (10% difference) while Trusts and estates were under-represented (11% difference). The data appears to under-represent smaller businesses. Older and larger organisations are slightly over-represented in the survey responses. This is understandable as smaller and younger businesses may not have had the capacity to respond to the survey. It is also possible that, due to the high failure rate of small businesses in NZ (on average 10% in the first year and 70% in the first five years [46]) that small businesses included in the original sample were no longer operating when the survey was initiated. Relatedly, it is important to recognise the non-response bias of failed businesses. Only 1% of responses to the survey were from failed businesses – compared to an expected failure rate of approximately 10%. It is inevitable that surveys of this nature will not draw responses from failed organisations as it is difficult to find contact details for failed organisations and/or elicit responses from failed organisations. Resilient Organisations currently have another research project following up the fate of failed businesses from the Canterbury earthquakes. For the detailed analysis of the representativeness of the survey sample see Seville et al. [47].

Table 5   Survey representation

Organisation demographic	Canterbury population statistics	Survey representation
Size of organisation	Average of 4 employees*	Mean of 83, median of 8 employees
Age of organisation	No data available	Mean of 31 years, median of 21 years.
Sectors represented (percentage of organisations in sectors where survey and population statistics differ)	• Rental, hiring and real estate services – 19%* • Agriculture, forestry and fishing sectors – 17%* • Manufacturing – 5%*	• Rental, hiring and real estate services – 6% • Agriculture, forestry and fishing sectors – 4% • Manufacturing – 14% • Insufficient responses (<5) from Mining, Administration and Support Services and Other Services sectors. *(Note, these have been excluded from the sector analyses)*
Maori organisations	No data available	6% of valid responses

Nature of ownership (percentage of organisations of given ownership type where survey and population statistics differ)	• Limited liability companies – 52%** • Trusts and Estates – 12%**	• Limited liability companies – 62% • Trusts and estates – 1%
Failed businesses	10% annually*	1%

Data from Statistics New Zealand for Canterbury [48].

Data from Statistics New Zealand for New Zealand [48].

As determined by responding 'We are no longer operating' to the question: Which of these statements best describes your organisation at the present?

4   Findings

4.1   Impacts on organisations

As noted in the literature review, there are a number of factors that impact organisations following disasters and all these were experienced in Christchurch to some degree. To enable a ranking of the effects experienced, a disruption index (DI) for all the impact factors was calculated (as described in Section 3.3.3). The results are shown in Table 6. Overall, organisations found 'Customer Issues' to be the most disruptive impact.   When the impacts were grouped into similar factors, 'Human/organisational' type impacts were the most disruptive for organisations, followed by 'External and environmental' impacts; and lastly by 'Physical' impacts related to the earthquakes (damage to premises, machinery and contents). Whilst organisations found 'Changes in Emotional Wellbeing of Staff' to be highly disruptive, interestingly 'Availability of Staff' was not a significant problem. Most organisations found structural damage to their building(s) and damage to their local neighbourhood to be more disruptive than damage to building contents (fixtures and fitting, inventory and stock, office equipment, machinery, etc).

Table 6   Disruption indices of impacts following the 2010/2011 Canterbury earthquakes

	Disruption Index, DI	
	Mean	Standard Deviation
Human/Organisational Impact Factors		
Customer Issues	0.53	0.37
Changes in staff emotional well being	0.50	0.34
Preceptions of building safety	0.40	0.35
Health and safety issues for employees	0.34	0.35
Supplier Issues	0.34	0.33
Availability of staff	0.31	0.32
Average DI for Human/Organisational Impacts	**0.40**	
External and Environmental Impact Factors		
Damage to local neighbourhood	0.44	0.4
Difficulty accessing premises / site	0.38	0.41
Damage to ground surface	0.33	0.37
Damage to or closure of adjacent organisations of buildings	0.30	0.40

Average DI for External and Environmental Impacts	0.36	
Physical Impact Factors		
Structural damage to buildings	0.42	0.39
Non-structural damage (fittings etc)	0.35	0.35
Damage to inventory or stock	0.35	0.37
Difficulty accessing IT data	0.35	0.36
Office equipment loss or damage	0.29	0.34
Machinary loss or damage	0.25	0.35
Average DI for Physical Impact Factors	**0.34**	

4.2 Impacts and recovery

To determine whether the degree of impact on organisations had an effect on their recovery status, a Spearman's rank order correlation was carried out. The analysis showed that there was a statistically significant but relatively weak negative correlation between impact and recovery (r_s=-0.256, p=0.000), see Figure 1. That is, the higher the impact, the lower the reported recovery situation. This is expected and aligns with the literature findings. The scattered and weakly correlated results provide some validation for the *recovery relative to impact index* used in this paper. The results demonstrate that all organisations have been impacted differently but some organisations have overcome those impacts better than others. By accounting for the impacts when assessing recovery, it will show the types of organisations that have been more resilient to the impacts they faced.
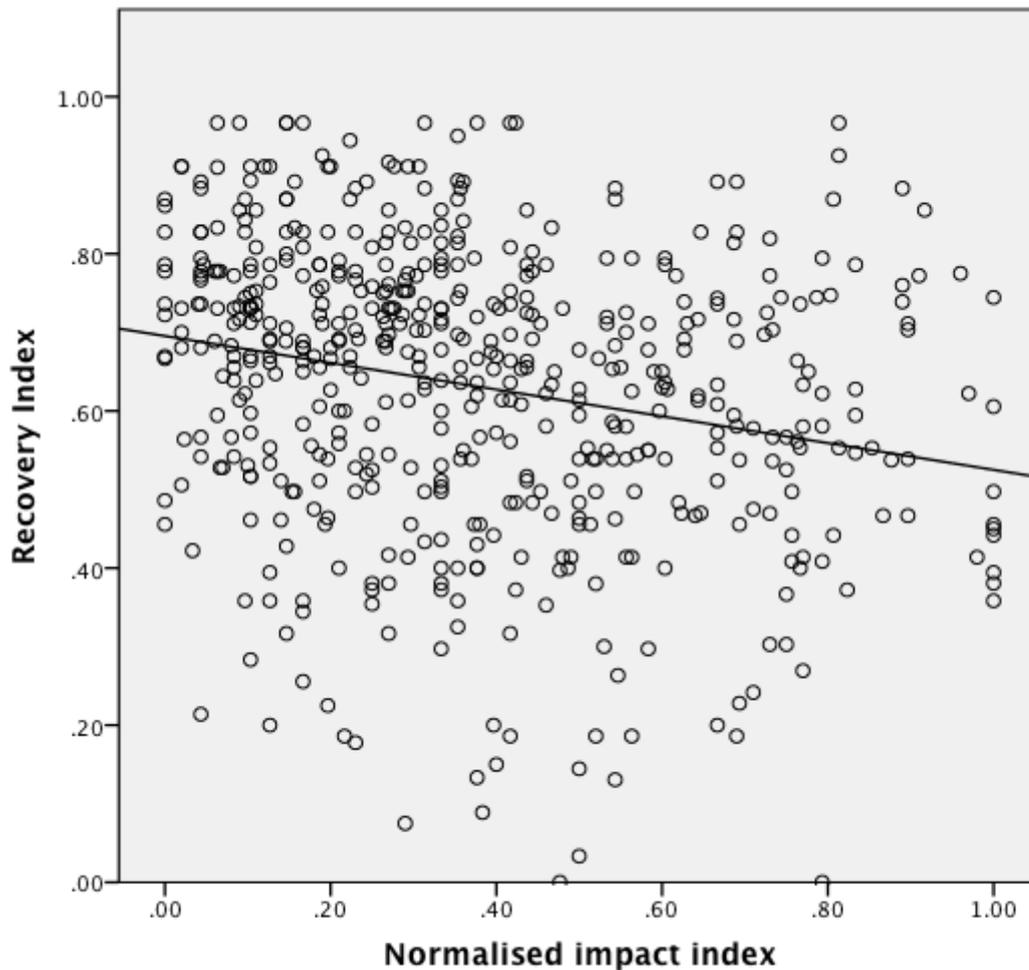
Figure 1 Correlation between Recovery and Impact (where 1 corresponds to the highest impact and the best recovery status at the time of survey)

4.3   Correlations between organisation size, impact and recovery

A Spearman's rank-order correlation was carried out to investigate the relationships between organisational size and the level of impact (II), recovery (RI) and recovery relative to impact (RII). It was found (to a 0.03 confidence level) that there was essentially no relationship between organisational size and level of impact sustained (r_s=0.094, p=0.03). In terms of recovery, the data showed no statistically significant correlation between the size of an organisation and its recovery status at the time of the survey (r_s=-0.055, p=0.209). However, when the initial impacts of the earthquakes were taken into account (using the RII) there was a very weak, statistically significant positive correlation between the size of an organisation and how well it recovered (r_s=0.111, p=0.011). Figure 2 shows the large spread of recovery outcomes (shown by the spread parallel to the y-axis) across various sizes of organisation (parallel to the x-axis).
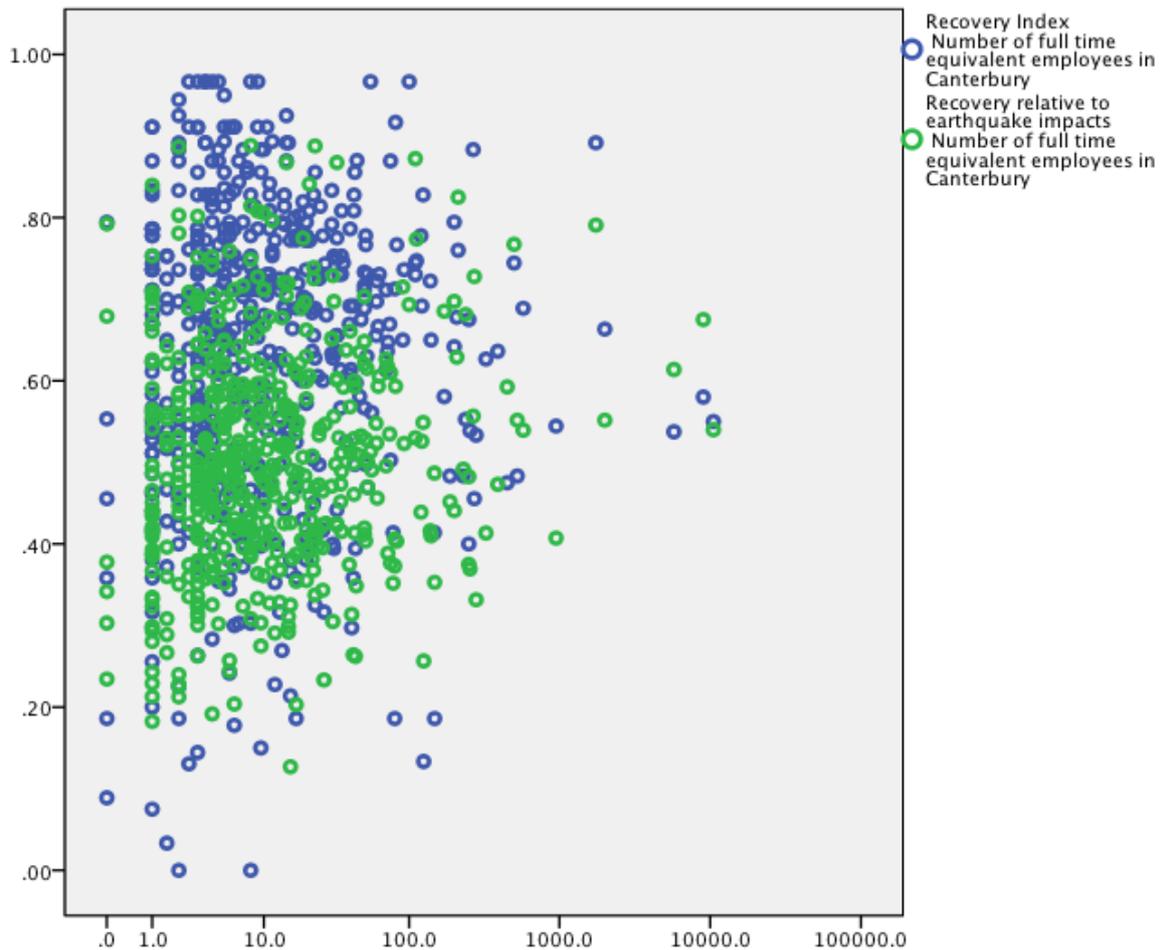
Figure 2 Relationship between Size of organisation (number of employees on a log scale), their recovery status and recovery relative to initial impact

To investigate the effect of size further, single owner-operator organisations were specifically analysed to see if they were impacted and recovered differently from other size organisations. Mann Whitney U tests were used to test whether the differences between the impact and recovery of two groups were significantly different or not. The results showed no statistically significant evidence that single-owner operator businesses (N=45) performed any differently to other organisations. Compared to organisations with more than one employee, single owner operator organisations were similarly impacted (U = 10140, p=0.329), reported similar recovery statuses (U=9786, p=0.177) and similar recovery relative to earthquake impacts (U=10787, p=0.759). Figure 3 shows the similarity of the recovery measures.
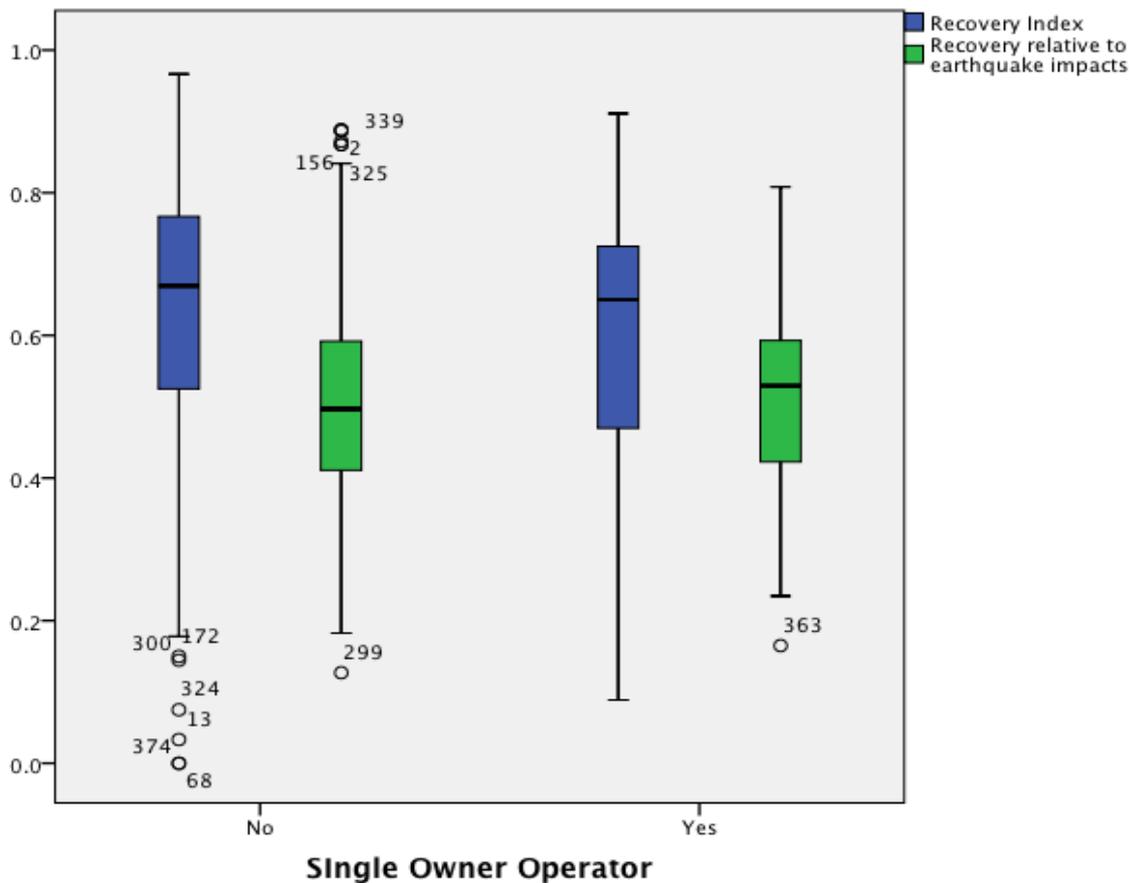
Figure 3 The recovery status and recovery relative to initial impacts of single owner-operator organisations vs all other organisations.

The results for the influence of size of an organisation on recovery differ from the majority of literature on organisational recovery. Generally, authors note that larger organisations are less impacted and recover more successfully than smaller organisations. The results here showed only a weak relationship between the size of an organisation's recovery and this was only evident when initial impacts were accounted for. The results are limited, however, by the non-response bias of failed and small businesses. It is interesting to note that of the five failed businesses that responded to the survey, the employee numbers were 2, 4, 8, 15 and 50. This shows a spread of sizes of failed businesses but does tend toward small organisations. Further investigation is required.

4.4   Correlations between organisation age, impact and recovery

A Spearman's rank-order correlation was also carried out to investigate the relationships between organisational age and the level of impact (II), recovery (RI) and recovery relative to impact (RII). The analysis showed (to a 0.02 confidence level) that there was no correlation between the age of an organisation and how heavily it was impacted by the earthquakes (r_s=0.098, p=0.023).

In terms of recovery, the analysis showed no statistically significant relationships between the age of the organisation and how well it recovered: both in terms of the current recovery situation (r_s=-0.059, p=0.170) and the recovery relative to the initial impacts sustained (r_s=0.054, p=0.209) see Figure 4.
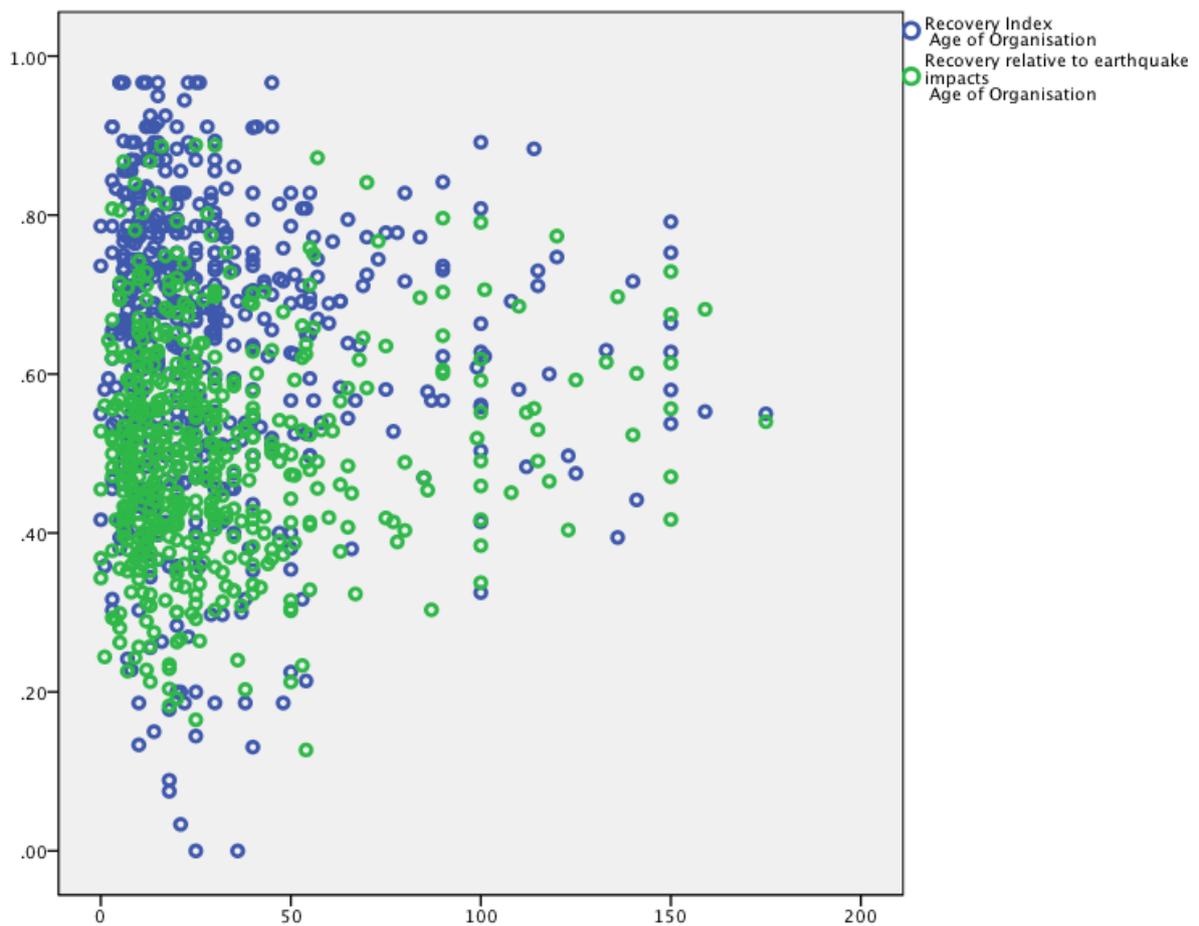
Figure 4   Relationship between organisation age, their recovery status and recovery relative to initial impact

These results also differ from the organisational disaster recovery studies discussed in the literature review. Generally the literature suggests that older organisations are less impacted and recover more effectively. This analysis shows essentially no correlation. As noted, the survey data has a limitation in that it slightly under-represents younger businesses and failed businesses; both these factors could influence the validity of these results. Of the five failed businesses that responded to the survey, the age of the organisations were 5, 7, 9, 25 and 36.

4.5   Correlations between Industry Sector, Impact and Recovery

A Kruskal Wallis H test was carried out to investigate if there was a statistically significant difference between sectors and their level of impact (II), recovery (RI) and recovery relative to impact (RII). The test results are summarised in Table 7. In terms of impact, the test found statistically significant differences in the impacts between sectors ($\chi^2(15)=45$, p=0.000). The most impacted sectors were Public Administration and Safety, Rental, Hiring and Real Estate Services, and Information Media and Telecommunications (mean rank impact scores of 358, 343, and 325 respectively). The least impacted sectors were Agriculture, Forestry and Fishing, and Accommodation and Food Services (mean rank impact scores of 167 and 190 respectively). The difference between this top and bottom group of

sectors was significant to a 0.05 significance level when a pair wise check was carried out (between Information Media and Telecommunications and Accommodation and Food Services) using a Mann Whitney test (U=93, p=0.03).

The literature suggests that sector can influence impacts sustained, however, there does not appear to be a clear consensus across disasters as to which sectors are most vulnerable. The sectors identified in the literature as being heavily impacted are wholesale and retail trades, and finance and real estate. This analysis identified real estate as a heavily impacted sector but the other sectors identified in the literature were not statistically significantly higher than other sectors.

In terms of recovery, there were also statistically significant differences in how sectors performed (χ^2(15)=48, p=0.000). The sectors that have recovered the best (based on their recovery status at the time of the survey) are: Accommodation and Food Services, Construction, and Financial and Insurance Services (with mean rank recovery scores of 360, 334 and 321 respectively). The sectors that have recovered least are Public Administration, Health Care and Social Assistance and Arts and Recreation Services (mean rank recovery scores of 204, 205 and 212 respectively). The difference between this top and bottom group of sectors was significant to a 0.05 significance level when a pair wise check was carried out (between Financial and Insurance Services and Arts and Recreation Services) using a Mann Whitney test (U=126, p=0.017).

If the initial impact is taken into account and the recovery position is reported relative to initial impact (RII) then the sectors with the most successful recovery change noticeably and the significance of the results also reduces (χ^2(15)=24, p=0.06). The sectors with the highest recovery relative to initial impact are: Information, Media and Telecommunications; Public Administration and Safety; Rental, Hiring and Real Estate Services (mean rank recovery-impact scores of 347, 330, 327 respectively). The sectors with the least successful recovery trajectories are: Agriculture, Forestry and Fishing, Manufacturing and Arts and Recreation Services (with mean rank recovery-impact scores of 201, 229, 237 respectively). The difference between this top and bottom group of sectors was significant to a 0.05 significance level when a pair wise check was carried out (between Rental, Hiring and Real Estate Services and Arts and Recreation Services) using a Mann Whitney test (U=192, p=0.052).

Table 7   Kruskal Wallis mean ranks for Impact, Recovery and Recovery Relative to Impact for different sectors

Sector	N	Impact Mean Rank	Recovery Mean Rank	Recovery relative to impact Mean Rank
Accommodation and Food Services	45	190**	360*	260
Agriculture, Forestry and Fishing	21	167**	279	201**
Arts and Recreation Services	18	279	212**	237**
Construction	44	219	334*	261
Education and Training	35	301	233	277
Electricity, Gas, Water and Waste Services	18	236	291	258
Financial and Insurance Services	22	294	321*	319
Health Care and Social Assistance	48	287	205**	249

Information Media and Telecommunications	8	325*	313	347*
Manufacturing	74	251	235	229**
Professional, Scientific ad Technical Services	59	304	264	299
Public Administration and Safety	5	358*	204**	330*
Rental, Hiring and Real Estate Services	32	343*	254	327*
Retail trade	43	296	247	278
Transport, Postal and Warehousing	28	260	305	275
Wholesale Trade	33	264	242	243
Total	533			
Tables excludes sectors where less than 5 responded (Administrative and Support Services, Mining and Other Services)				
* highest ranking sectors to 0.05 significance level (Mann Whitney pair wise check)				
** lowest ranking sectors to 0.05 significance level (Mann Whitney pair wise check)				

Figure 5 shows the range in recovery and *recovery relative to impact* scores for the various sectors. As the graph illustrates, there are some significant changes in the relative recoveries of certain sectors when initial impacts are accounted for. In particular, it is interesting to note the sectors that have the largest difference between their recovery and *recovery relative to impact* scores (such as Construction and Accommodation and Food Services). These sectors were not very heavily impacted but reported a strong current position. First, this highlights that if only the current recovery situation was assessed the Construction sector may be viewed as being particularly resilient in the wake of the earthquakes. Whereas, the recovery relative to impact score shows that the sector's recovery is relatively average. Second, the large difference in the two recovery measures (relative to other sectors) indicates that there may be some external factors specific to that sector that are contributing to the high recovery scores. In this case the literature suggests that sectors such as Construction show strong recovery due to increased activity in the sector and stimulation in growth was certainly evident in the construction sector in Canterbury [49].

By assessing the recovery of sectors both in terms of current recovery situation and *recovery relative to impacts,* a better understanding of the data can be attained. This approach helps to distinguish those sectors that are performing well because they were not impacted (low to moderate RII) from those that have overcome significant impacts to be in a strong recovery position (high RII). This approach can also help to identify sectors that may be performing well due to externalities such as increases in demand for services (where RI is much greater than RII).
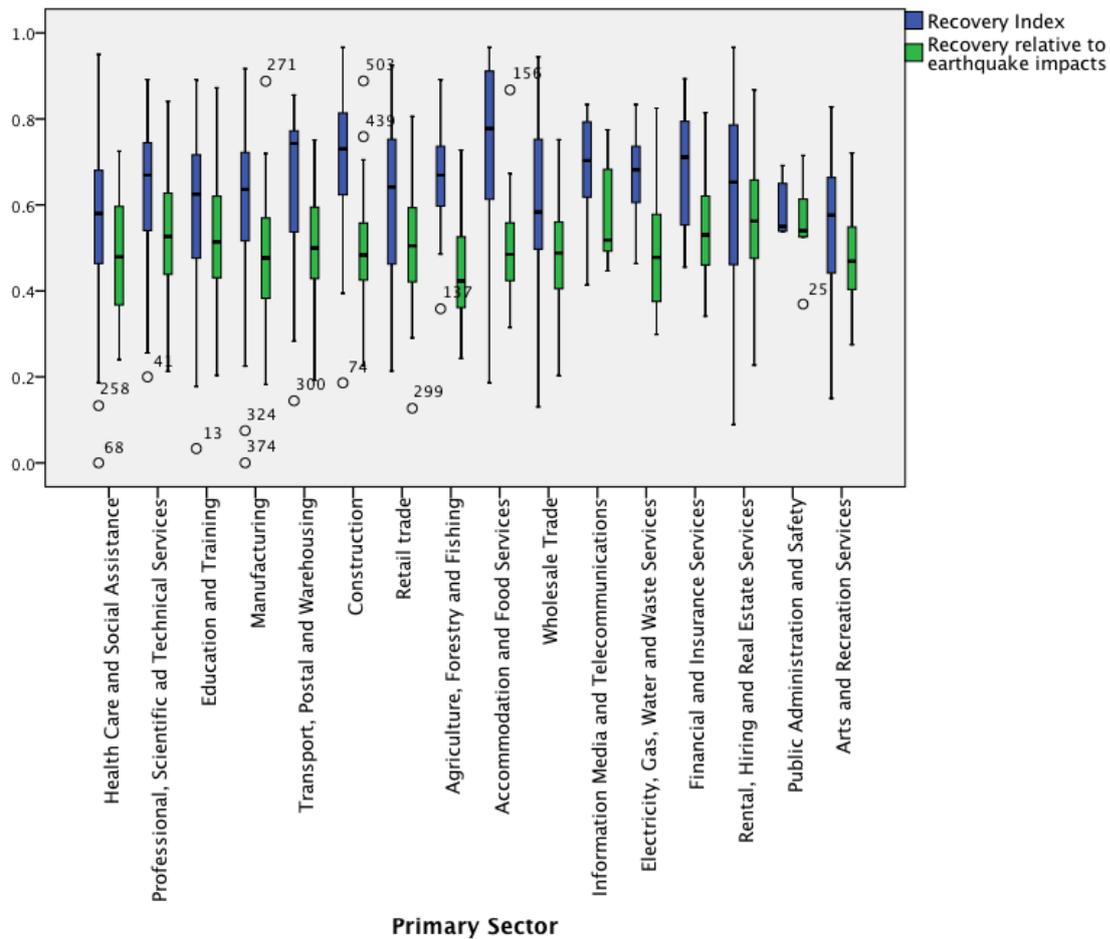
Figure 5 Sectorial differences based on recovery status and recovery relative to initial impact

The results do show statistically significant differences between the sector recoveries, but the leading and lagging sectors are not clear – particularly when the recovery is assessed both as the recovery status (at the time of the survey) and with respect to initial impacts. More analysis is needed to understand the different recovery paths that lead to these results; in particular, untangling externalities such as increased or decreased service demands from internal organisational weaknesses and strengths (or resilience) within each sector.

4.6 Correlations between property ownership status, impact and recovery

A Kruskal-Wallis H Test was carried out to investigate whether there were significant differences between the level of impact (II), recovery (RI) and recovery relative to impact (RII) of organisations with different property ownership statuses following the earthquakes. The analysis showed that those organisations that 'own and rent' properties (N=54) were most likely to be heavily impacted ($\chi^2(2)=5$, p=0.067) (mean rank 294), followed by those organisations that 'rent' (N=277, mean rank 265) and those that 'own' their property (N=189, mean rank 244). A pair wise check on these results, using a Mann Whitney U test, indicated that there is a significant difference between those that 'own and

rent' and those that 'own' (U= 4101, p=0.028). There were no significance relationships for those that 'rent' their business premises.

In terms of recovery, the analysis showed no statistically significant relationships between the property ownership status of the organisation and their current recovery position ($\chi^2(2)$=1.3, p=0.521). However, when the initial impacts were taken into account (using RII), there was a statistically significant difference between how these groups recovered ($\chi^2(2)$=7.8, p=0.020), though the differences are not great: those that 'own and rent' recovered best (mean rank 284), followed by those that 'rent' and then those that 'own' (mean rank of 272 and 236 respectively). A Mann Whitney U test between those that 'rent' or 'own' their properties confirmed that those that 'rent' premises recovered better relative to impact than those that 'own' their property (U=22641, p=0.013, mean rank (rent) = 246 and (own) = 215). There was no significant difference between those that 'rent' and those that 'own and rent' their premises. See Figure 6.
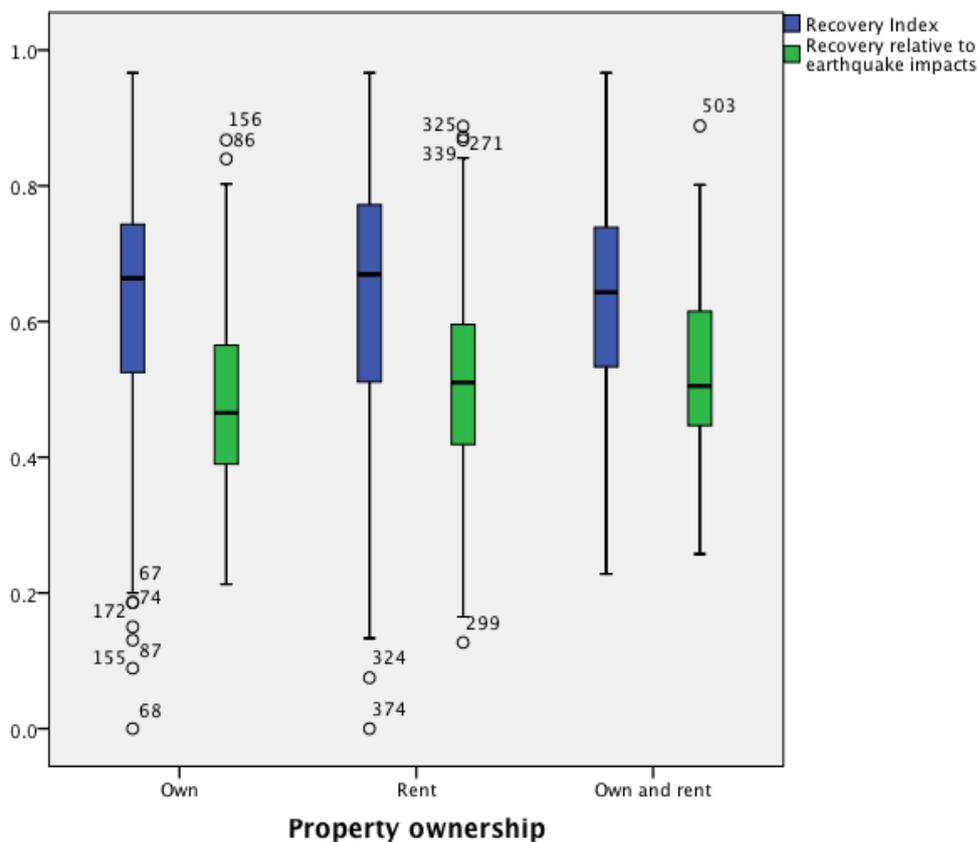

Figure 6   Recovery of organisations that own or rent their business premises

As for the age and size of organisations, these results on property ownership differed from the majority of literature on organisational recovery. Generally, authors note that organisations that rent their premises are more impacted and recover less successfully than those that own their premises. The results here showed that those that 'own and rent' properties were both more heavily impacted and recovered more effectively. This is an intuitive result as those that 'own and rent' have multiple premises that could be damaged but they were also able to utilise multiple premises to manage the disaster impacts. Contrary to the literature, the results here showed that those that only rented their

property were not statistically significantly more or less impacted than those that owned their properties. In addition, those that rented recovered more effectively (relative to initial impact) than those that owned their properties. Another finding that differs from the literature. Further analysis is required to determine why this might be true.

5   Conclusions

The results presented in this paper show that the impact on, and medium-term recovery of, organisations following the 2010/2011 Canterbury earthquakes differed from observations and analyses following other disasters. The impacts sustained were similar to other studies but this study allowed us to rank the impacts. The most disruptive impacts following the Canterbury earthquakes were customer issues and other human / organisational type impacts (over and above physical or external environmental impacts). The data either showed weak or no correlations between organisational age and size and their recovery, where many studies have found these to be determining factors in both impact and recovery. There were statistically significant differences in how sectors were impacted and recovered relative to other sectors, as observed in some studies. The most impacted sectors following the Canterbury earthquakes were Public Administration and Safety, Rental, Hiring and Real Estate Services, and Information Media and Telecommunications. The best performing sectors in terms of recovery depended on whether initial impacts were accounted for or not. In terms of property ownership, those that 'own and rent' were more heavily impacted but recovered better than those that 'rent' or 'own' their business premises. Interestingly, and contrary to the literature, the results showed that those that 'rent', were no more or less impacted than other organisations and they actually recovered more effectively than those that only owned their properties.

The use of the *recovery relative to Impact Index* (RII) used in this study has yielded some interesting results. The characteristics of the relationships investigated changed noticeably when initial impacts were taken into account. In particular, the RII highlighted how much more effectively some sectors have recovered relative to others given their level of impact, and the analysis helped to identify sectors that have experienced external boosts to their recovery such as increases in demand for services. This metric will be particularly useful when analysing the resilience attributes of organisations following the earthquakes.

This analysis has given a high level overview of how one set of factors (organisational demographics: age, size, sector and property ownership) affects disaster impact and medium-term recovery. Further analysis is required to look at a number of other factors that may influence impact and recovery and, subsequently, resilience. First, a more in depth analysis on how impact and recovery is assessed and measured, both in this study and other authors' studies is needed. Here, a very rich set of impact and recovery data has been consolidated into single indices. A richer analysis, based on individual impacts and recovery measures could be carried out. This would help to get a clearer, fuller picture of the significance of different impacts and their influence on recovery. Second, other factors such as mitigation measures, financing/ resource availability and adaptive measures (new collaborations, changes in business operations etc) could be included in analyses of organisational recovery. As many existing studies observe, the determinant of recovery is not just the degree of impact but also includes a number of other preparedness and organisational culture factors as well as consideration of the disaster context and other externalities. Third, these analyses need to be mapped to existing

organisational resilience concepts so that a deeper understanding of what makes an organisation more capable of recovery – what makes them more resilient – can be distilled.

Acknowledgments

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