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Using GIS to Measure the Impact of the Canterbury earthquakes on House Prices in Christchurch, NZ

Sandy Bond [1], *Sofia Dermisi* [2]

[1] Ph.D., MBS, ANZIV, Professor of Property Studies, Lincoln University
Dr_SandyBond@yahoo.com

[2] Professor of Urban Design and Planning, Runstad Endowed Professor of Real Estate, University of Washingto, sdermisi@uw.edu

ABSTRACT

The Christchurch area in New Zealand (NZ) experienced two significant earthquakes on September 4th, 2010 (7.1R) and February 22nd, 2011 (6.3R) with a devastating impact to both houses and land. Negative media attention to the potential financial risks of living near or on the new Technical Category 3 (TC3) land or on land in a flood zone has fuelled the perception of uncertainty over the negative property value impacts. However, the extent to which such attitudes are reflected in lower property values affected by these land categories is controversial.

This paper outlines research to identify attitude changes based on the sale price patterns as well as the relationship between sale prices and house characteristics before and after both of the earthquakes. We take a three-step approach by applying: a) an average trend analysis, b) GIS hot-spot analysis to identify possible spatial differentiations between the before and after effects of the earthquakes and, c) hedonic modeling to quantify the effect of house characteristics on sale price while controlling for and comparing, three land zones (TC1 to TC3).

The data suggests that average sale prices increased after both quakes in TC1 and TC2 rather than TC3 zones. GIS hot-spot results on house valuations provide evidence of limited differentiations after the two earthquakes compared to the before trends for Christchurch. In contrast, differentiations exist after the second earthquake in Selwyn for one of the TC1 zones as well as for a TC2 zone of the Waimakariri district after both earthquakes. The econometric modeling suggests that higher sale prices are achieved by: newer houses across all land zones and more recent sale agreements only in TC1 and TC2 zones. Other observations include the negative effect of exterior façade material such as fibrolite on sale prices on the overall dataset as well as the individual TC1 and TC3 zone, while mixture and roughcast have a positive effect. The roofing materials explored tend to have a diverse rather than a homogenous effect on sale prices. In conclusion, the results suggest that although caution might exist for the TC3 zone the quality of the house can overcome the media stigma attached to the TC3 zones.

Key-words: earthquakes, risk perception, stigma, GIS, house prices

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Introduction

There were four major earthquake events in Canterbury in 2010 and 2011 (see Appendix I). The first major earthquake, measuring 7.1M_W, occurred on 4 September 2010 with the epicenter 40 kilometres west of Christchurch, New Zealand's third-largest city, near the town of Darfield.[1] Whilst there was significant damage to buildings and infrastructure there were no direct fatalities. However, the 22 February 2011 6.3M_W earthquake severely damaged Christchurch, killing 185 people. The earthquake was centred only 10 kilometres south-east of the centre of Christchurch, 2 kilometres west of the port town of Lyttleton. Significant liquefaction affected the eastern suburbs, producing around 400,000 tonnes of silt. Lateral spread caused much of the building damage (Tonkin and Taylor, 2013). Other large earthquakes were the 6.41 magnitude earthquake on the 13 June 2011 and the magnitude 6 earthquake on the 23 December 2011. The Canterbury earthquake events and locations are shown in Appendix I. As at May 2014 there have been 540 earthquakes and aftershocks over 4MW (14,134 over 2MW) since the September 2010 event.

According to a report by the Royal Society of New Zealand & Office of the Prime Minister's Science Advisory Committee (2011) scientists did not know about the faults that caused the two Canterbury earthquakes as prior to September 4th, there were no surface signs of what is now known as the Greendale Fault or the fault that generated the Lyttelton February aftershock and there was no evidence for seismicity on these faults (i.e. 'foreshocks'). Appendix II shows the location of the Alpine fault line that runs diagonally through the South Island of NZ relative to the city of Christchurch that is located approximately 100km away. According to Berryman, manager, Natural Hazards Research Platform for GNS Science, Christchurch was considered a low-risk city because it is a reasonable distance from the Alpine fault (Rebuild Christchurch, 2011). Understanding the likely response to, and preparing and planning for, a natural disaster in an area with no recent history of such events has proven problematic.

Following the 4 September 2010 earthquake the Canterbury Earthquake Recovery Commission was created under the Canterbury Earthquake Response and Recovery Act 2010. The Act was repealed and replaced with the Canterbury Earthquake Recovery Act 2011 and it was under this Act that the Canterbury Earthquake Recovery Authority (CERA) was established to lead the recovery effort. CERA has progressively mapped all of greater Christchurch land into land zones according to assessments of land and building damage and risk of liquefaction. The zones are: Green (Go Zone) and include Technical Categories 1, 2 and 3 (TC1, TC2, TC3) (Appendix III) where the repair/rebuild process is able to begin; Red (No Go Zone) where land repair would be prolonged and uneconomic, and White (Unzoned) that included the CBD or hillside land where geotechnical mapping and further assessments are underway.

There were 7,839 properties zoned red as at September 2013, including 714 Port Hill properties. As at April 2013, 6,666 flat land homeowners had taken up the government offer to purchase property at the most recent rating valuation (assessed in 2007), whereas the Port Hill homeowners have until 31 August 2014 to do so. The majority of greater Christchurch properties are in the Green Zone, whereby property owners no longer have to wait for the results of any area-wide land assessment reports by EQC or their engineering consultants Tonkin & Taylor before they begin repair or rebuild.

The Green zoned land on the flat has been assigned into three foundation technical categories based on the expected future liquefaction performance. The aim of these categories is to ensure appropriately engineered foundations. The categories indicate which properties will require site investigations to assess the foundation type needed to suit the specific ground conditions. The technical categories are as follows (and as shown on the map in Appendix III):

- Technical Category 1 (TC1 – grey) is where future land damage from liquefaction is unlikely and a soil

1 Before the 2011/12 earthquakes, Christchurch had overtaken Wellington to become New Zealand's second largest city (Statistics New Zealand, 2012) with Christchurch (386,100) holding only a slim lead over Wellington (386,000) at 30 June 2009. However, Statistics New Zealand (2011) figures reveal that Christchurch lost 10,600 people in the year to June 2011.

test should suffice. Current standard foundations for concrete slabs or timber floors can be used, but concrete slabs must be reinforced and tied to the perimeter foundation and the structure.

- Technical Category 2 (TC2 – yellow) is where minor to moderate land damage from liquefaction is possible in future significant earthquakes. The only further site-specific geotechnical investigation required is a shallow soil strength test 3-4m (to check if peat is present). To mitigate against possible damage from liquefaction, Standard (NZS3604) piled foundations are suitable for houses that are built of lightweight materials (not masonry or brick veneer) and have timber floors instead of concrete floors, or enhanced (rib raft) slabs.

- Technical Category 3 (TC3 – blue) - moderate to significant land damage from liquefaction is possible in future significant quakes. TC3 land tends to have a thin crust and liquefiable (loose sand) layer below. Site-specific geotechnical assessment and specific engineering foundation design is needed. Area wide drilling will assist with this, with the data gathered enabling detailed analysis of how liquefiable the soil is.

  TC3 considers both damage to the house and likely future performance of the land. For example, repairs may just require lighter roofing material to reduce the weight of the house/load on foundations. There are around 28,000 properties in TC3 areas, and around 12,500 homes in TC3 areas have major foundation and pile damage that will require more investigation of the ground around them (CERA, 2012).

Due to increased flood risk, mostly in the Red Zone, and changed land levels assessed through the use of LADAR photography and survey that enabled the ground level/thickness of crust (indicating liquefaction risk) to be estimated, new flood zone maps were required.

This paper outlines research to investigate how resident's perceptions towards investing in homes that may be at risk of flooding and/or liquefaction impacts on house prices. In addition, the price impact of resident's attitudes towards the new technical categories is explored. The paper starts with a review of the literature on risk perception generally, then focuses on risk perceptions towards earthquakes more specifically, and on stigma caused by natural disasters. The review then considers how stigma can impact negatively on a property's value. Following this, the research is introduced and the results presented. The paper concludes with a discussion of the results, providing insights on the impacts on house prices from the Canterbury earthquakes.

Literature Review

There is a body of literature of how at-risk populations prepare for, respond and adjust to, natural hazards such as floods, tsunamis and earthquakes. Understanding how individuals perceive risks is important not only to effective disaster planning and communication, but in terms of this research, also to understanding how such perceptions are reflected in property market behaviour. Property in natural hazard areas may suffer stigma, a "market imposed penalty" (Bell 1999) determined by peoples' perceptions of risk, and so a brief discussion of risk perceptions follows next.

Risk Perception

This section outlines research relating to risk perceptions that considers it from both the scientific (technical) and social or behavioural viewpoints, but with a focus on the latter. Technical analysis focuses on the probability of an event happening and the consequences (number of deaths, environmental damage, property damage, financial costs). On the other hand, social or perceptual analysis of risk focuses on the complex interplay involving psychological, sociological and cultural perspectives (Freudenburg, 1988).

Kunreuther (1992) explains the behavioural approach as resulting from the inability of individuals to fully grasp the concept of probability and statistical data relating to risks so instead they tend to rely on salient information (past experience) and easily accessible sources (friends and neighbours). By not relying on statistical data risks that are uncontrollable, unknowable, or have catastrophic potential, such as earthquakes, are feared by the public even though they are unlikely. Kasperson (1992) explains that

hazard events interact with psychological, social, institutional and cultural processes in ways that can heighten perceptions of risk and shape risk behaviour. The behavioural responses to disaster events in turn generate secondary social or economic consequences (e.g. stigmatisation; loss of confidence in institutions involved in disaster management; and insurance costs). Krimsky and Golding (1992) add that the public's perception towards risk vary according to a wide range of variables including voluntariness (the ability to choose the risk by free will rather than by force), catastrophic potential, and dread.

Kasperson (1992) defines risk as both a threat of physical harm (an event, or a report of an event) and the result of cultural and social processes when these events are communicated to others (social amplification). Slovic (1992) found that mechanisms of social amplification, such as heavy media coverage and attention drawn to problems by special interest groups, can increase the stigma associated with the risk. Covello (1998) reports similar results showing that while the media are critical to the delivery of risk information the media tends to be biased toward stories that contain drama, conflict, expert disagreements, and uncertainties and often the coverage of risks is oversimplified, distorted, and inaccurate. Not surprisingly, the result is inaccurate estimates of the level of risk by the public. According to Covello the major challenges to effective risk communication include: a lack of trust and credibility of information sources; overly complex scientific and policy messages; distortions by the media and other stakeholders, and public perceptions and misperceptions. Covello observes that one of the factors that causes this distrust is a lack of coordination among public or private organizations with risk management responsibilities.

In summary, none of the above risk authors deny the need for technical risk analysis, they simply argue for the need to include the social view of risk in risk analysis. The methodology adopted for the current research examines risk from both a social and an economic perspective.

Risk perception toward earthquakes

A survey by Upprety and Poudel (2012) to determine what motivates earthquake preparedness involved an interview of 350 residents in the highly earthquake prone Kathmandu valley in 2007/2008. The two most recent major earthquakes in Nepal were the 1934 *Richter Mw* 8.4 earthquake with an epicentre some 10 kilometers south of Mt. Everest, claiming 16,875 lives and the 1988 Udayapur earthquake in Eastern Nepal that claimed 721 lives. Kathmandu valley was severely affected by the 1934 earthquake with 4,296 deaths and lost 8 lives as a result of the 1988 event. The authors found that variables such as experience of an earthquake and concern for future damage significantly influenced the preparedness among the respondents in the study area. Their result is consistent with other studies that show that people start to increase preparedness measures once they have experienced earthquakes themselves (Mileti and Darlington, 1995, Dooley et al., 2006).

Another study of what motivates seismic risk mitigation by Egbelakin et al. (2011a) focused on building owners of earthquake prone buildings and the factors that encourage them to retrofit. In their 2011b study using a similar data set and survey approach, as outlined below, they identified socio-behavioural barriers affecting seismic retrofit implementation to be perceptions of earthquake risk, a lack of trust in seismic strengthening techniques and a lack of pro-social mitigation behaviours from public authorities.

In their follow-up study (Egbelakin et al. 2011b) to identify what motivates or hinders stakeholders' decisions to act, they interviewed a variety of stakeholders involved in seismic upgrade decisions (building owners, property valuers, engineers, architects and managers of insurance, financial and governmental organisations). Taking a multiple case study approach (four New Zealand cities based on their seismicity and other earthquake risk factors) and developing a multi-phased conceptual framework (intention phase, decision formation phase and implementation of seismic adjustments phase) the authors examine how seismic retrofit decisions can be motivated and sustained. According to the authors, the intention phase relates to an individual's willingness to decide to upgrade which is influenced by factors such as perception of risk, self-efficacy, perceived responsibility, and outcome expectancy. This phase can be enhanced by critical awareness and effective risk communication. The decision formation phase can be enhanced by attributes such as perceived benefits of retrofitting, such as ensuring safety and financial returns (increased rent or property value). Motivators to enhance this phase are said to include

financial incentives (grants, low interest loans, tax credits) and creating value for seismic risk in the property market. The results of the survey found that intensifying the use of critical awareness motivators improves people's perceptions and understanding of seismic risks and mitigation measures. Further, the authors report that creating value for seismic risks in the property market through the mandatory disclosure of earthquake risks in property transactions was found to significantly affect the adoption of seismic adjustments.

Rossetto, Joffe and Solberg (2011) provide a brief overview of previous studies on earthquake risk perception which they define as "perception of the likelihood and consequence of a future adverse event" (from Adams 1995). The review is to highlight the psychological drivers of seismic adjustment behaviours on the part of individuals that might facilitate mitigative actions. Their review indicates that people's perceptions of seismic risk, sense of belonging in a community, sense of trust, sense of responsibility and sense of control all contribute to the adoption of seismic adjustment measures. In terms of demographic differences in risk perceptions, females and minority groups generally feel more at risk regarding earthquakes than men and majority groups (for example, Dooley et al. 1992 and Paradise 2006); higher income, education and homeownership rates have been linked to decreased risk judgements in US respondents (e.g. Lindell and Prater 2000).

A more in-depth review of the international literature on the social psychological factors that shape human adjustments to seismic risk is provided by Solberg, Rossetto and Joffe, (2010). Some of the more relevant literature, as it relates to the present study outlined in this paper, is discussed here. Their international research review indicates that a large proportion of survey respondents do nothing or very little to adjust to seismic hazards, and when they do take action, it is significantly more likely to be response and recovery-related than mitigative. In relation to material risk (a scientifically derived probability estimate of future risk) of failure of buildings and soils during seismic activity, they report findings of Turkish and Romanian researchers that type, height, age and perceived structural vulnerability of respondent's residences, as well as their knowledge of proximity to soft soils and faults, heighten risk perception.

McClure et al. (2012) conducted a study to help understand what will motivate residents to take preparedness activities. They interviewed 380 residents in Christchurch (200), Wellington (100) and Palmerston North (80) to assess changes in their judgments of the risk of earthquakes before and after the 2010 Darfield, Canterbury earthquake. The results showed that for Wellington and Palmerston North respondents', expectancies changed after the earthquake, as many learned from the Darfield earthquake, that earthquakes happen not only in known vulnerable cities such as Wellington, they can happen elsewhere in New Zealand. Further, the results show that before the Darfield earthquake, while Christchurch citizens were aware of civil defence messages about preparedness they thought that these messages applied to others, not themselves, as Christchurch was not known to be vulnerable to earthquakes and so these respondents were less prepared.

Property related stigma

According to Chan (2001), "stigma is a loss to property value due to the presence of a risk perception-driven market resistance". The concept of environmental stigma appeared in the valuation literature in the late 1980s (e.g. Kinnard 1989 and Patchin 1992), followed by regular bibliographic efforts to document its impact on property value (Kinnard 1992; Kroll & Priestley 1991; and Roddewig 1996). A consistent finding was that debt financing was more difficult to obtain for threatened or stigmatised properties (Wilson & Alarcon 1997; and Bell 1999).

Anything that might change the publics' perceptions towards risk will alter the degree and duration of stigma. Changes in public perceptions of risk can also result from media attention. For example, in relation to stigma from proximity to a source of perceived hazard Sanders (1996) and Kinnard and Dickey (1995) note that when publicity about the hazards has been "intense, ongoing and increasing", observed levels of measurable property value impact has tended to persist over time. Conversely, the reverse occurs when publicity has decreased or ceased: any negative price impact associated with proximity has typically diminished or gone away within a relatively short period of time. Market

conditions have also been shown to impact on risk perceptions. For example, Jackson (2001) and Sanders (1996) have found that strong market demand reduces, or mitigates, lender and investor risk and weak demand increases or exacerbates their risk.

Methodologies Advocated to Study Property Value Effects

The literature dealing with the impact of natural disasters on housing markets reports a variety of methods to assess post-disaster changes in house values. Levy (1984 and 1986) discusses an approach to value land impacted by landslide.[2] He suggests a cost to repair approach and making an allowance for any further diminution in value after the repairs are complete, that reflects "stigma". Stigma may arise due, for example, buyers fearing a reoccurrence of the problem as well as potential difficulties obtaining finance or insurance coverage (as occurred after the Canterbury earthquake).

Sanders (1996) provides a framework for the valuation of properties damaged by geotechnical or related effects similar to Levy but recommends the assessment of stigma through the use of a case study approach, regression analysis or contingent valuation. Stigma can be particularly relevant to defects associated with geotechnical and structural problems where the layperson cannot visibly examine repairs to determine their adequacy. Sanders notes that stigma does reduce with time and will be greatest immediately after the damage or loss occurs.

Bell (1999) states that, "…all the factors that have an influence on a property's desirability, and therefore its value, are traced back to the market's perceptions". The use of opinion surveys in risk perception studies have become more popular in the US since the early 1980's when the Supreme Courts of several states allowed "widespread public fear" of hazards to human safety and health as evidence for identifying and measuring proximity damages to affected residential properties. Further, these cases held that the reported or perceived "widespread public fear" need not be "reasonable"[3], i.e. based on known and supportable scientific fact. Opinion surveys generally involve surveying market participants about their perceptions towards particular environmental features and may also ask questions about the perceived impact of such a feature on property price (see for example, Bond 2014).

Contingent valuation is a survey approach that attempts to predict willingness to pay. However, this method is based on buyers' stated preferences rather than actual sales price data and so may not accurately reflect likely property price impacts (what buyers say they will do versus what they actually do may not be consistent). As suggested in Bond, Sims and Dent (2013), the dichotomy between public opinion and actual behaviour when faced with a real situation has been one of the major criticisms of qualitative analysis as a reliable determinant of likely public response to environmental features (e.g. Slovic 1987; Whitehead et al. 2008).

The literature dealing specifically with the measurement of the impact of environmental hazards on residential sale prices (including proximity to transmission lines, landfill sites cell phone towers, wind turbines, and ground water contamination) indicates the popularity of hedonic pricing models, as introduced by Court (1939) and later Griliches (1979) and further developed by Freeman (1979) and Rosen (1974). Briefly, this method assumes that the price of a property is determined by a number of key physical characteristics of the house (e.g. house size, number of bedrooms, construction materials, age, etc.), as well as neighbourhood and locational attributes (e.g. accessibility to schools, shops and local amenities; presence/level of any soil, water or air pollution; crime levels, etc.). Breaking down a property into its main characteristics allows the influence of each attribute on the total price to be determined.

The more recent hedonic studies, including those by Bond (2007), Hoen et al. (2009), Simons and Sementelli (1997), focus on proximity to an environmental hazard and demonstrate that this reduces

2. Levy (1986) defines "landslides" broadly to include all forms of damage which result from soil problems (i.e. "land failure").

3. For example: Willsey v. Kansas City Power (631 P.2d 268); the 1987 combined cases of Florida Power and Light v. Jennings and Florida Power and Light v. Roberts (518 So.2d 895).

residential house prices by varying amounts depending on distance from the hazard.[4]

Bond and Wang (2005) use a multi-method approach that enabled the results to be triangulated. As outlined in Bond, Sims and Dent (2013) the theory behind the multi-method approach is that quantitative and qualitative methods can be utilised as different approaches to the same research problem and regarded as complementary (Firestone 1987). Bryman (1988) considers that most of the literature on the subject indicates that researchers recognise that there is a considerable amount to be gained from merging quantitative and qualitative methods. As noted by Creswell (1994), if the results from the different approaches yield similar answers, then the analyst can be more confident of having obtained a valid result.

Bond (2014) surveyed Canterbury residents' in 2012 to determine their perceptions of risk towards owning and living in residential property subsequent to the 2010 and 2011 earthquakes to identify how these perceptions impact on the price residents are willing to pay for affected property. The current study is a follow-up of the 2012 study using a hedonic house price approach. GIS was also adopted to aid the analysis of distance to various technical categories of land and flood zones. The results from both studies can then be compared.

The Christchurch Experience

Risk Communication

The lack of coordination among risk management agencies tasked with communicating to the community that Covello (1998) describes above was evidenced in Christchurch during the 2010-2011 quake events where often the same information was delivered to a person from several sources, and often the messages varied, so it was difficult to determine which message was correct (Wylie, 2012). It was as a result of local and central government agencies involved in supporting Christchurch during and after the 2011 earthquakes acknowledging they do not know how best to engage with Culturally and Linguistically Diverse (CALD) communities, that Wylie (2012) undertook research to identify what 'best practice guidelines' for communication and engagement during a civil defence disaster and in the rebuild/recovery phase were needed. To do this, the methodology involved an analysis of existing resources and written materials on Communicating with CALD communities in a civil defence emergency, as well as consultation with key stakeholders in two stages (1) in 2012, utilising semi-structured interview techniques, and (2) less formal interviews and group discussions to seek feedback and input into draft guidelines produced on the basis of the initial consultation findings. The development of Best Practice Guidelines was the final outcome of this research that would overcome many of the weaknesses identified by stakeholders.

An independent review of the response to the February 22 Canterbury earthquake indicated that there were weaknesses and tensions between Christchurch City Council and Civil Defence which "put people and property at risk" (Cooke, 2012). The Corrective Action Plan was released in December 2012 to improve the strength of Civil Defence in New Zealand by adopting a more efficient interagency approach. The outcomes of the plan will be incorporated into the National Civil Defence Emergency Management Plan.

Stigma from the technical land categories

The estimation of the duration of stigma is as important as the measurement of its magnitude from a valuation perspective. However, to confirm any change to stigma similar studies of similar design to allow comparison between them need to be conducted over time, and their results made public. The research reported below is a starting point for this process of on-going research.

There were a number of reports in the Christchurch news about the risks of buying TC3 property and reduced value of this category of property. For example, The Press (2012a) reported that there is uncertainty about TC3 land due to how it is defined by CERA and that this "may deter some buyers, insurers and lenders and also increase building costs, potentially having a negative impact on selling price". Another

4 Only Dotzour found no significant impact of the discovery of contaminated groundwater on residential house prices. This was likely due to the non-hazardous nature of the contamination where the groundwater was not used for drinking purposes.

report claims that "Christchurch buyers are paying a premium for less-damaged areas while shunning trouble and uncertainty in the most damage-prone neighbourhoods", backing this claim up with reference to a special report by rating valuation agency, Quotable Value, that says that average prices for TC3 homes were now under 2007 rating valuations, compared with 10 per cent and 7 per cent over for TC1 and TC2 respectively (The Press, 2012b).

Christchurch property valuer, Edwards (2012), confirms the view that there is TC3 land market stigma, especially where the land is near waterways or the property has no insurance. She claims that big real estate firms do not like promoting TC3 land and that lenders are treating TC3 land differently too. However, she predicts that this stigma will reduce as there is more transparency regarding Earthquake Commission's information on new acceptable foundation solutions and the timeframes for assessing properties.

In an attempt to allay uncertainty around the Canterbury residential rebuild, concerns about the length of time things are taking and questions being asked by home owners about TC3 land and the potential for property values of it to be affected, CERA produced a booklet "The TC3 Residential Rebuild" (Canterbury Earthquake Recovery Authority, 2012) to help home owners understand the rebuild process including which organisations are responsible for what part of the assessment and rebuild process.

Data and transformations

The initial ArcGIS dataset included all residential transaction activity for New Zealand, utilizing data from the Real Estate Institute of NZ and an online sales system ValBiz by Headways Systems Ltd. A number of data fields were provided per house which can be grouped into two categories: *a) house characteristics*, such as latitude, longitude, address, land and floor area, exterior and roof façade, type (residence, land, unit, townhouses and apartments), valuation, year constructed, listing and agreement dates, number of bedrooms, listing and sale prices (NZ$), time on the market (sell days), area/municipal district and *b) land zones*, based a Canterbury Earthquake Recovery Authority (CERA)'s assessment of land and building damage and risk of liquefaction [Technical Categories (TC1 through TC3), N/A - Port Hills & Banks Peninsula, N/A - Rural & Unmapped , N/A - Urban Nonresidential, Orange and Red Zone etc.].

The original dataset went through a series of transformations: (1) determination of a narrower and more homogeneous urban fabric area with the boundary including Christchurch, Selwyn and Waimakariri (Figure 1), (2) matching and confirming of the house's geocoding and the districts used in the study to avoid mislabelling, (3) determination of a homogenous housing type for the analysis which included residences and excluded units, townhouses and apartments. Vacant land and red zones were also excluded from the final dataset, (4) the use of the ValBiz sales data was instrumental in the updating of the missing information of the original dataset including the year of construction as well as exterior and roof façade materials, (5) the updated dataset was then integrated into a single file with all the districts which allowed the statistical analysis, (6) identification of the sales timing agreements as before or after the two earthquakes (September 4th, 2010 and February 22, 2011 respectively) and their overlay above the land zones (Figures 2 through 4). Due to the house densities shown in Figure 2 the visual identification of the land zones underneath the houses cannot be easily made. In contrast, Figure 3 shows that a significant number of houses are located at two areas designated as TC1 and a lack of TC2 or TC3. In the case of Waimakariri, Figure 4 clearly suggests the existence of pockets of house sales in TC2 and TC3 designations, (7) the initial descriptive statistical analysis revealed the existence of some mislabeling (e.g. zero values for land area, sale price, construction year or sell days), which were treated as missing information for that structure to avoid any impact on the statistical analysis. The final dataset includes 12,379 house sales, with 80.35% (or 9,946) located in Christchurch, 12.78% (or 1,582) in Waimakariri and 6.87% (or 851) in Selwyn. The sales agreements spanned from September of 2008 through June 2012.

Figure 1. Study area with house allocation

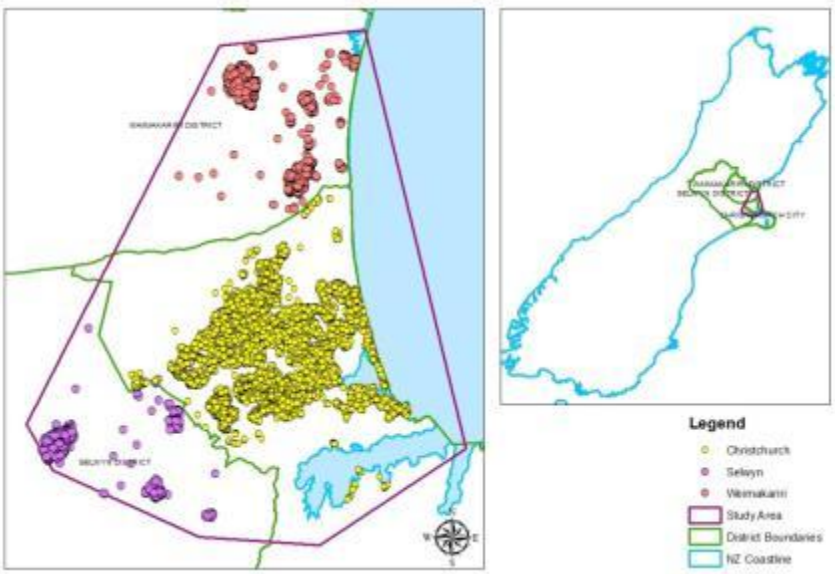


Figure 2. Location of Christchurch houses sold before and after the 9/4/10 and the 2/22/11 earthquakes

Figure 2a. Houses sold before the 9/4/10 quake	Figure 2b. Houses sold after the 9/4/10 quake

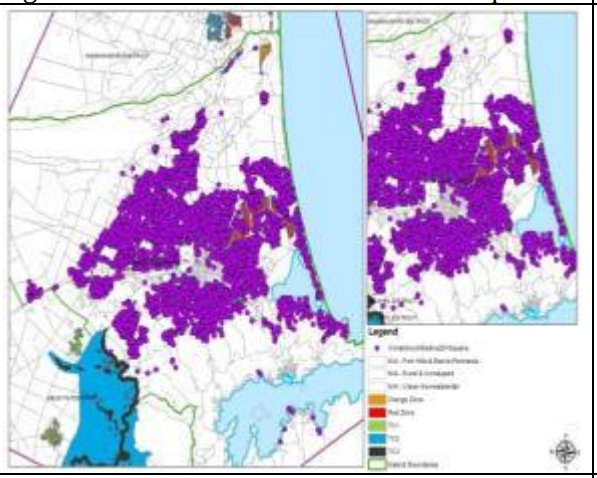
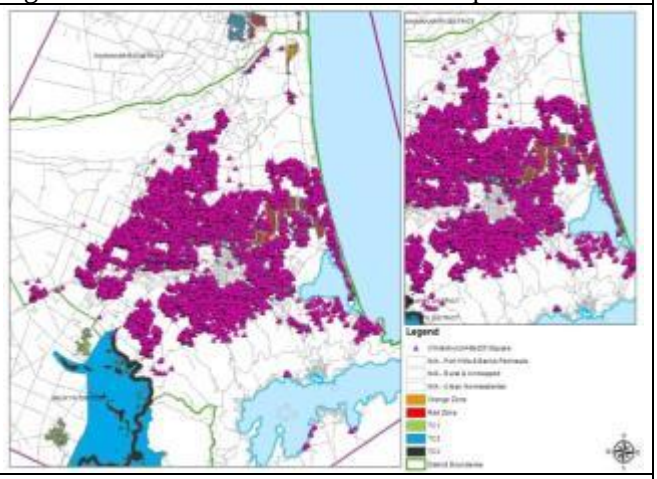

	

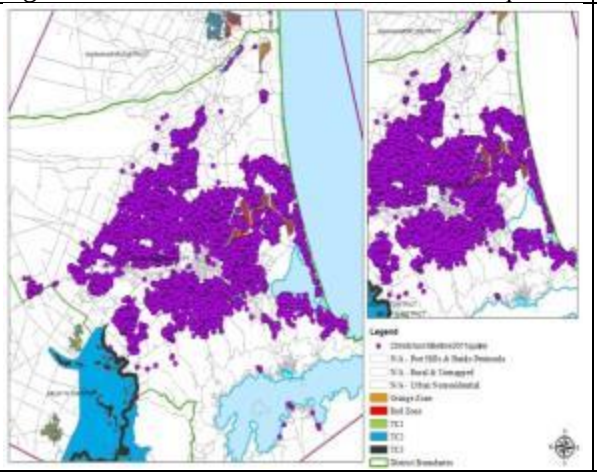
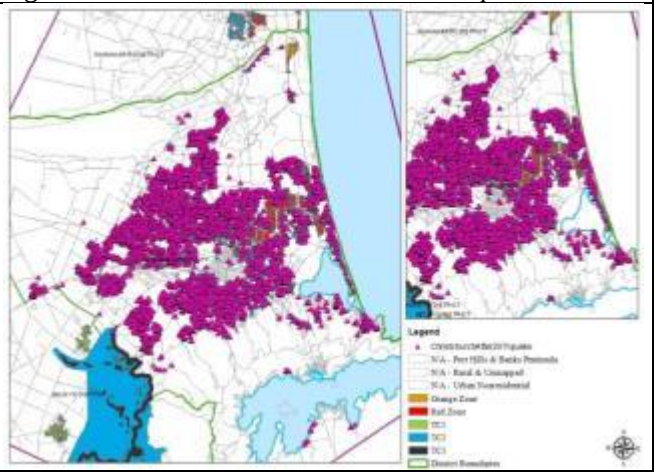
Figure 2c. Houses sold before the 2/22/11 quake	Figure 2d. Houses sold after the 2/22/11quake
	

Figure 3. Location of Selwyn houses sold before and after the 9/4/10 and the 2/22/11 earthquakes

Figure 3a. Houses sold before the 9/4/10 quake

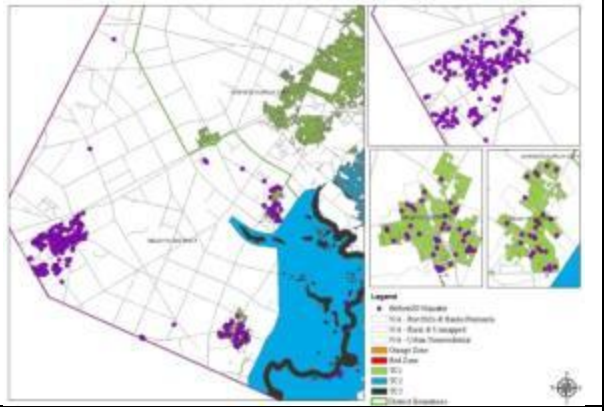


Figure 3b. Houses sold after the 9/4/10 quake

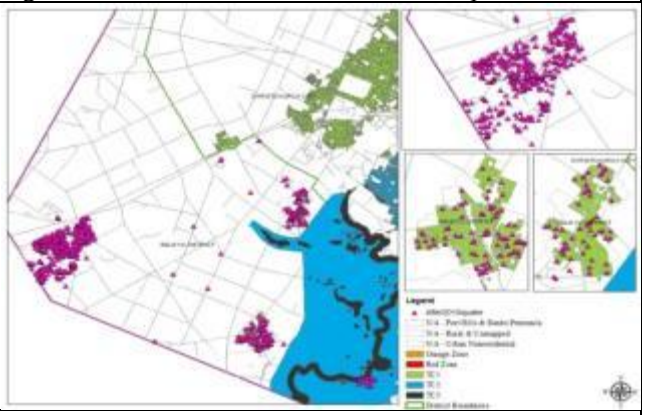


Figure 3c. Houses sold before the 2/22/11 quake

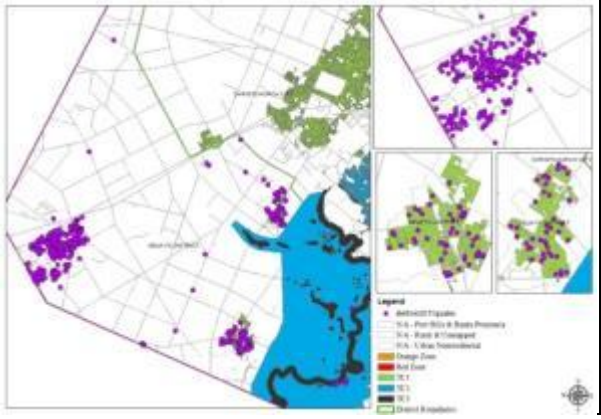


Figure 3d. Houses sold after the 2/22/11quake

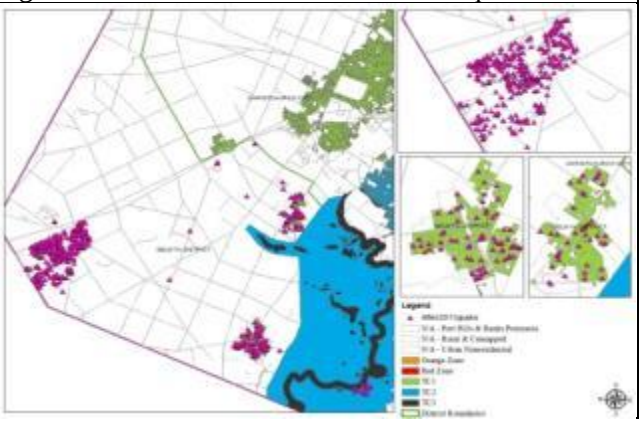


Figure 4. Location of Waimakariri houses sold before and after the 9/4/10 and the 2/22/11 earthquakes

Figure 4a. Houses sold before the 9/4/10 quake

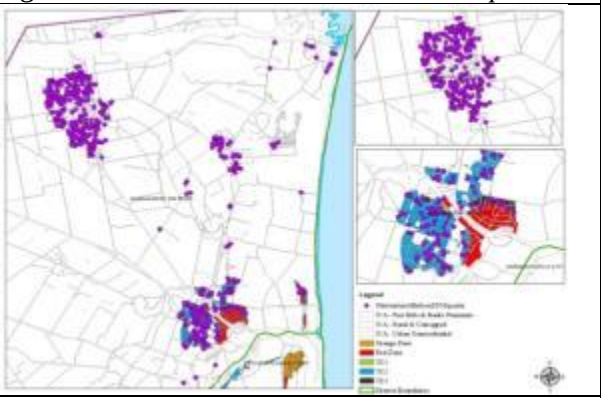


Figure 4b. Houses sold after the 9/4/10 quake

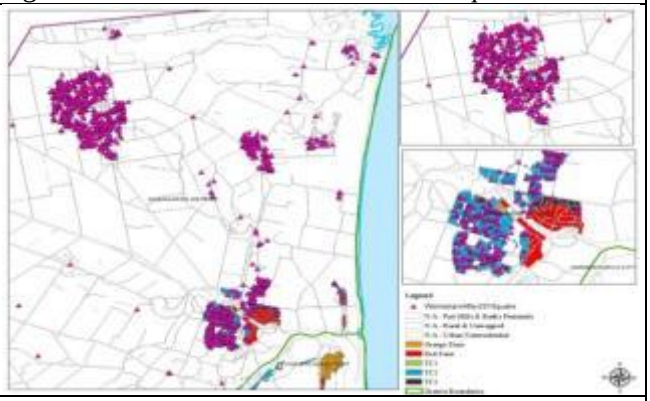


Figure 4c. Houses sold before the 2/22/11 quake

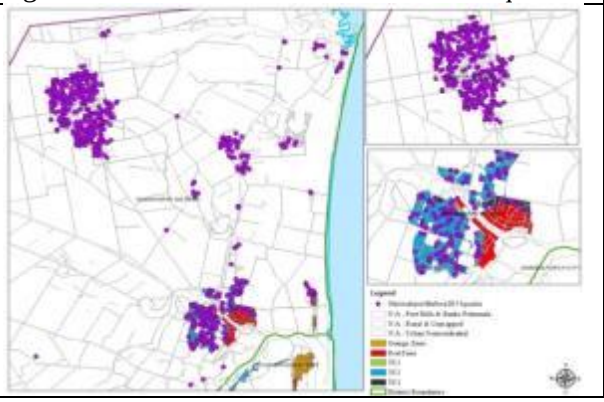
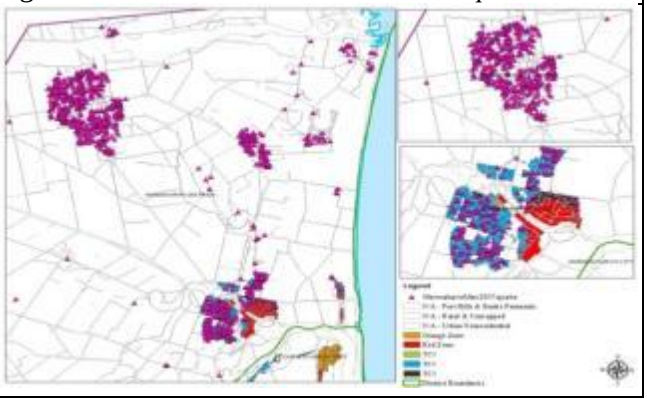


Figure 4d. Houses sold after the 2/22/11quake



Methodology

The broad aim of this research is to identify residents' perceptions of the risks associated with various types of land zones[5] (e.g. TC1, TC2 and TC3) such as possible future liquefaction and/or flooding. These attitudes are quantitatively assessed through the analysis of the house characteristics/profiles (e.g. sale prices, valuation, construction year, number of bedrooms, exterior and roof façade material and sell days) before and after the two area earthquakes (9/4/10 and the 2/22/11) while controlling for the three land zones.

Specifically, three distinctive approaches are used in this study:

a) descriptive statistics: average and standard deviation trends as well as t-tests were applied among certain house characteristics for the overall dataset regardless of the land zones and then separately for each of the three designations (TC1, TC2 and TC3) both before and after the two quakes as well as for the three districts (Christchurch city, Selwyn and Waimakariri). This initial approach provided a first overview of the differentiations among the three designations regarding house characteristics as well as attitudes (through sale prices and material preferences) when accounting for the two quakes (Tables 1 through 4 – Appendix IV). Identifying the number of observations for each of the exterior and roof façade materials allowed the determination of the most common material which were then considered for further analysis,

b) spatial data analysis: The advent of GIS with its ability to spatially link property addresses with geographic coordinates has revolutionised hedonic modelling. In a review of hedonic modelling, Malpezzi (2003) observes: 'Perhaps one of the most exciting areas for extending hedonic models is making use of the spatial structure of the data, using the emerging technology of geographic information systems and spatial autocorrelation.' The application of Geographic Information Systems (GIS) in this case allows: i) the visual representation of both the housing sales and the land zones throughout the study area before and after the two quakes (as seen in the data section - Figures 1 through 4) and ii) the identification of spatial distribution patterns by utilizing an optimized hot-spot analysis, which applies the Getis-Ord Gi statistic (Figures 5 through 7- Appendix V) and shows the statistically significant hot and cold spots. The resulting maps are based exclusively on house valuations while accounting for the neighboring houses. The benefit from this approach is the visual determination of areas with similar valuations while the three land zones are shown in the background. Figures 5 through 7 exclusively show each of the three districts rather than the overall data which show in more detail the housing distribution over the land zones.

c) hedonic modeling: the use of regression analysis to assess the effects that structure characteristics have on sale prices is fairly common because it allows us to control for a number of characteristics simultaneously (Tables 5 through 10 – Appendix VI). Wilhelmsson (2000) identifies four broad types of property factors that households normally take into account in the purchasing decision: *house characteristics* (number of bedrooms, square feet, attached garage, etc.); its *location relative to urban services* (such as school districts, jobs, etc.); its *environmental attributes* (such as the view or slope of the yard); and the impact of *macroeconomic attributes* (such as the prevailing interest rate for mortgages). This study applies an Ordinary Least Square (OLS) regression model which explores the effect of certain house characteristics on sale prices before and after the two earthquakes in the following ways: i) the overall dataset regardless of land zone, ii) within each of the most popular land zones (TC1 through TC3) and iii) within each district (Christchurch, Selwyn and Waimakariri) and each land zone as long as the land zones have sufficient number of observations. All models where tested for possible multicollinearity and appropriate adjustments were made to avoid it. The model parameters are (Eq. 1):

$$\ln(sale\ price) = a + \beta_1 Const.year_i + \beta_2 Bedrooms_i + \beta_3 Agr.Year_i + \beta_4 Sell\_days_i + \beta_5 Land\_area_i + \beta_6 Exterior\ Facade_i + \beta_7 Roof\ Facade_i + \square \quad \text{Eq.1}$$

where: sale price is the price a property was sold for, const. year is the construction year of the structure, bedrooms is the number of bedrooms, agr. year is the agreement year which takes values from 2008 through 2012, sell_days is the number of days it took for a structure to sell, land area is the

[5] The statistical analysis focused only on three land zones (TC1, TC2 and TC3) because of the significant number of observations compared to the all available land zones.

lot size in the structure is located in sq. meters exterior façade refers to a variety of dummy variables which take the value 1 if the structure exterior façade is built with the material specified or otherwise zero, roof façade are similar to the exterior dummies with the value 1 given to houses with the specified material. The determination of which façade material to include in the model was made based on the information derived from the descriptive statistics which highlighted the material most predominately used.

Results

A first step in assessing the perception of risk associated with house sales after the two earthquakes (9/4/10 and the 2/22/11) was the determination of the average trends among selected house characteristic before and after the two quakes. Table 1 – Appendix IV, highlights these trends on an overall basis as well as within each of the land zones (TC1 to TC3) with the most house sales. Tables 2 through 4 provide the same information but separately for each of the district (Christchurch, Selwyn and Waimakariri). Specifically, Table 1's overall comparison of both quakes suggests that sale prices increased on average after both quakes for newer houses, larger in size houses (based on the number of bedrooms) but the sell days increased only after the first quake. In contrast, valuation seemed to have decreased on average after both quakes. Shifting the focus to within each of the land zones, the results of Table 1 show that sale price increased after both quakes in the TC1 and TC2 areas with newer houses being sold after the second earthquake in TC1. In the case of TC2, the houses sold were newer after both quakes. The TC3 area did not suggest any statistically significant differences between the average values before and after the quakes, with the exception of sell days which increased after the first quake. The analysis of the exterior and roof façade material used based on the number of observations determined that only certain material could be further assessed for their impact on sale prices (exterior: brick, concrete, fibrolite, mixture, roughcast, stone and wood; roof: fibrolite, iron, malthoid, mixture and tile).

Table 2– Appendix IV, provides the same type of information as Table 1, for the Christchurch district. On average, sale prices increased and sales of newer construction increased after both quakes, similarly to Table 1. This result holds for the TC1 and TC2 areas of Christchurch after the second quake and for TC2 after the first quake. Table 3– Appendix IV, provides the results regarding average trends for the Selwyn district; the overall average sale price increases after both quakes. However, in this case due to the limited number of observations in TC2 and TC3 areas only the TC1 area trends can provide more concrete insight. With the exception of sale prices which show an increase after the first quake in the TC1 area all other variables do not indicate any differentiation when comparing the before and after quake trends. Three exterior (brick, concrete and roughcast) and two roof materials (iron and tile) were predominantly used and were considered for further analysis.

Table 4 – Appendix IV, provides the results of the Waimakariri district. Overall sale prices in this district are higher after both quakes as well as for the TC2 area. TC3 in contrast to TC2 did not experience any statistically significant changes on average trends after, compared to the before trends for both quakes, although sale prices decreased slightly. The exterior materials predominantly used in this area are identical to the Christchurch area with the only exception being Stone. The roof materials, on the other hand, most predominantly used are identical to those used in Selwyn.

In conclusion, the comparison across all tables (Tables 1 through 4 – Appendix IV) shows that sale prices increased on average overall as well as in each of the three districts studied, with the highest average prices being experienced in the Selwyn district and the lowest in Waimakariri. The comparison among the three land zones shows less consistency between TC1 and TC2 areas, although TC3 areas overall and those in Christchurch and Waimakariri do not show any statistically significant difference when comparing the average sale prices before and after both quakes. When analyzing the TC3 area average sale prices for the overall data as well as Christchurch those values seem to be the highest compared to either TC1 or TC2, this lowers the possibility of a significant increase especially after a quake in an area designated with a moderate to significant damage possibility after another quake. The absence of any statistical difference among average sale prices in TC3 areas is therefore an indication of less negative property value effect in these areas regardless of the negative media attention. The review of the average values of the other structure characteristics' before and after quake shows less consistency.

Figures 5 through 7 – Appendix V, show the hot-spot analysis results for house valuations in each of the three districts. Figure 5 results suggest the existence of clusters (hot-spots) with similar valuations northwest of the downtown area (shown in red dots with a 99% confidence level) as well as south. The red dots suggest homogeneity of house valuations in these areas in contrast to other areas were there seems to be more variability. The comparison of the before and after the first quake trends does not show significant difference in the allocation of hot-spots except of southwest of the downtown which suggest some very similar valuations in close proximity to the TC2 zone. The valuation trends before and after the second quake (2/22/11) do not suggest major differences except of the houses closer to the ocean which show more variation after the second quake. Figure 6, does not show significant differences in the valuation hot-spots (red-dots) before and after the first quake across the Selwyn district, even in areas identified as TC1. However, differences exist between the before and after trends of the second quake with less red-dots in one of the TC1 zones with house sale presence. Figure 7, shows the hot-spot analysis results for the Waimakariri district which suggest a differentiation in the hot-spot activity after both quakes when compared to the before trend especially in TC2 zones. The comparison of all figures related to hot-spots suggests that neither of the quakes affected significantly the house valuation trends in the Christchurch district, while in contrast houses in Selwyn and especially in one of the TC1 zones did not maintain similar values (homogeneity) after the second quake. Houses in the Waimakariri district are experiencing a similar effect with Selwyn but for a TC2 zone after both quakes.

This next section presents the results from the multiple regression models used to quantify the relationship between house sales price, and their characteristics (Tables 5 through 10 – Appendix VI). Tables 5 and 6 focus on the overall dataset before and after the two quakes (9/4/10 the 2/22/11) regardless of districts, but account for each of the three land zones. Three of the variables have a consistently positive effect on sales prices across all models in both tables and regardless of the quakes: newer houses; houses with a larger number of bedrooms, and houses with a larger land area. For example, in Table 5 columns 1 through 4, the results suggest that for every more recent decade a structure is built sale prices increase by 4.63% and 4.51% (Table 5 – columns 1 and 2) before the first and second quake, respectively, and 4.91% and 5.11% (Table 5 – columns 2 and 4) after the quakes, respectively. Looking at the construction year row in both Tables 5 and 6 it is evident that the newer houses seem to be achieving the highest sales price effect in TC3 zones, with an increase of 7.05% (Table 6 – column 6) and 7.31% (Table 6 – column 8) suggesting that people feel confident that newer houses in these areas are more resilient in the face of future quakes versus older ones.

The effect of both additional number of bedrooms and land area on sale price is expected and therefore additional discussion is not provided. The effect of agreement year on sale prices is worthy of discussion however. Table 5, columns 3, 5 and 7 suggest that houses with fairly recent agreement years, but before either of the two quakes, transacted with lower prices by 1.73%, 5.4% and 3.61% respectively. In contrast, more recent sale agreements which took place after the quakes experienced a sale price appreciation in the overall dataset (by 4.16% and 4.36%, columns 2 and 4, respectively), a higher one in the TC1 zone (by 4.93% and 5.73%, columns 6 and 8, respectively) and TC2 zone (4.76% and 4.38%, Table 6 columns 2 and 4, respectively). This result can be caused by two possibilities which cannot be investigated further based on the available data: i) the need for housing after a quake is significant and therefore the supply and demand balance leads to more agreements after a quake with higher prices and/or, ii) buyers are showing resilience and are willing to pay a premium for quality and surviving housing stock regardless of location in a TC1 and TC2 zone. In contrast, houses with more recent agreements and after the second quake in a TC3 zones are experiencing a significant sale price decrease of 10.1% (Table 6 – column 8) indicative of challenges such as land stability and higher risk of liquefaction in these zones.

Another variable with a statistically significant effect on sales prices was the sell days (Time on the Market), which influences only the before quake periods before both events (Tables 5 – columns 1, 3 and Table 6 – column 3). The expectation is that as sell days increase value decreases to attract a potential purchaser, which was true before both quakes in contrast to the period after the quakes which did not have any statistically significant effect.

Shifting the focus to exterior façade[6] material, one of them has a negative effect on sale prices especially after each of the quakes in the overall dataset, TC1 and TC3 zones – fibrolite. Houses with fibrolite on their exterior façade experience a sale price decrease by 11.9% after the first and second quake in the overall dataset (Table 5 – columns 2 and 4), a 15.6% decrease after the first quake and a 21.5% after the second in the TC1 zone (Table 5– columns 6 and 8) and a 66.53% decrease after the first quake and a 68.2% decrease after the second in the TC3 zones (Table 6 – columns 6 and 8). Among the exterior façade materials with a more constant positive effect on sales prices mainly after, but in some cases before both, the quakes are mixture (of materials) and roughcast. The lowest positive effect of mixture is experienced in the overall dataset after the second quake by 13.7% (Table 5 – column 4) and the highest in TC2 zones by 22.88% (Table 6 – column 2). Wood has also a positive effect on sale prices, but only for the overall data and the TC2 zones both before and after both quakes (Tables 5 and 6 – columns 1 through 4). Although the effect of wood remains statistically significant after both quakes it decreases (Table 5 – overall data: before the first quake 19.48% compared to 12.30% after the first quake; before the second quake 17.94% compared to 11.52% after the second quake; Table 6 -TC2 zone: before the first quake 24.11% compared to 21.77% after the first quake; before the second quake 23.24% compared to 20.32% after the second quake). The effect of roof façade material on sale prices is less consistent, with the only exception being tile, which has a negative effect in the overall dataset and the TC2 zone. In the overall dataset a tile roof is associated with a 3.41% decrease in sale price before the first quake and a 2.12% decrease after the first quake (Table 5 – columns 1 and 2); the effect of tile on sale prices before the second quake is 3.81% (Table 5 – column 3). In Table 6, columns 1 through 4, the tile effect on TC2 is almost constant with a 4.75% and a 4.40% decrease of sale prices before and after the first quake respectively; the effect of tile on sale prices before and after the second quake is 4.89% and 4.19% respectively.

Tables 7 and 8 provide the regression results of the Christchurch district overall as well as each of the three land zones within the district limits. The results of both tables are very comparable to Tables 5 and 6 due to the large influence of the overall dataset based on this district. For example, newly constructed houses, those with larger number of bedrooms and those with large land areas have a positive effect on sale prices. Additionally, the agreement year has a positive effect after both quakes overall as well as in the TC1 and TC2 zones; however the effect turns negative in the TC3 zone after the second quake similar to Table 6. Finally, the exterior and roof façade in Tables 7 and 8 share similar effects as those discussed in Tables 5 and 6.

Table 9[7] provides the regression results of the Selwyn district, which are less comparable to Table 5. Although new construction and number of bedrooms share their effect with Table 5 for the overall data (columns 1 through 4), an increase in the number of bedrooms is statistically significant only before both quakes in the TC1 zone (by 5.1% and 5.07% respectively). Also, the agreement year has no affect on sale prices either before or after the second quake (columns 7 and 8). Regarding the exterior and roof façade material, brick has a negative effect before both quakes (18.4% and 14% respectively), but no effect after either quake. Similar is the effect of concrete on sale prices with a 12.6% and 12.8% respective decrease. In contrast, no roof façade material has a statistically significant effect.

Table 10 provides the regression results of the Waimakariri district, which are also less comparable to Table 5, with the exception of new construction, number of bedrooms, agreement year, and land area. In Table 10 – columns 6 and 8 (TC2 zone) suggest that an increase in the home sell days (Time on the Market) by 10 days has a negative effect on sale price but only after both quakes by 0.49% and 0.61% respectively. The exterior façade materials brick and roughcast have a positive effect on sale prices but mainly before the quakes for both the overall data and the TC2 zone (columns 1, 3, 5 and 7). In contrast, fibrolite has a negative effect on sale prices only on the overall dataset (columns 2 and 4).

[6] Exterior and roof façade material are dummy variables and therefore their coefficient results are adjusted to reflect this in the text.

[7] Table 9 includes only an overall assessment of the district and that of TC1 zone because of the absence of significant number of house sale in the other land zones.

Summary and Conclusions

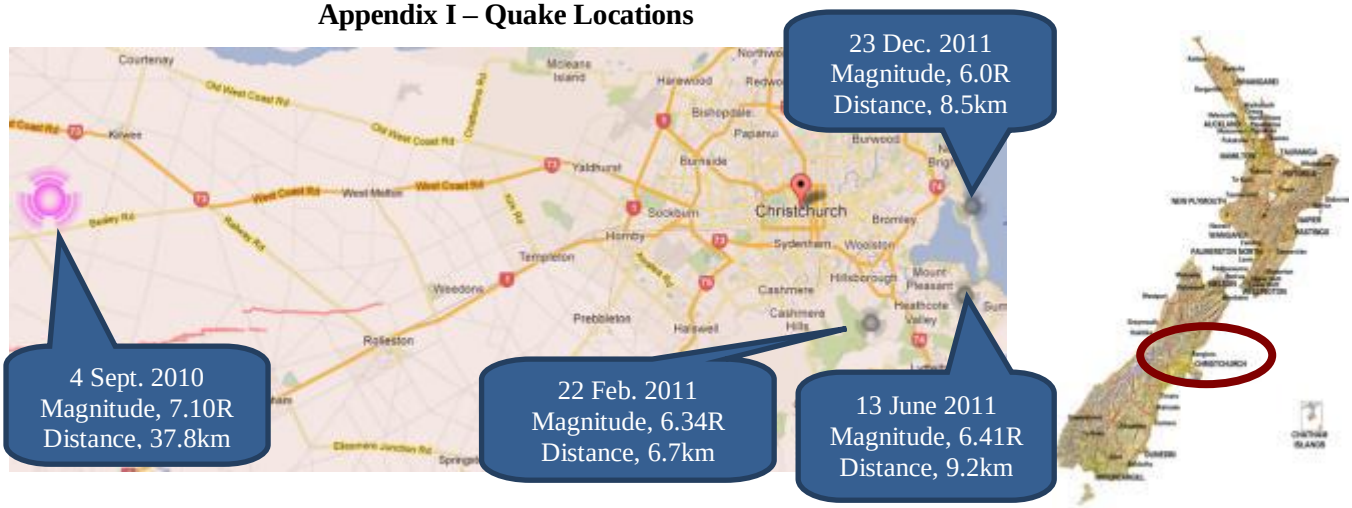
The overall data comparison regardless of land zone (TC1 through TC3) suggests that sale prices increased on average after both New Zealand earthquakes (9/4/10 and the 2/22/11). This trend is also experienced within TC1 and TC2 zones but not TC3, which did not show any statistically significant price differentiation when comparing the before and after quake periods of both quakes. The comparison of the three districts (Christchurch, Selwyn and Waimakariri) suggests that on average sale prices also increased regardless of land zones although differences exist among the three zones. Another consistent result across all TC3 zones (overall as well as the three districts) is the lack of any significant difference in the average sale prices of houses before or after both quakes. This result suggests that regardless of the negative media coverage of these zones the sale prices did not experience major shifts indicative of risk aversion among the individuals purchasing houses in these zones.

The hot-spot analysis of the valuation trends provides evidence of such concentrations across all three districts with limited differentiation between the two quakes. Christchurch district seems to experience similar valuation trends in certain pockets north east, south, southwest and southeast of the downtown but the southeast hot-spots close to the ocean diminish substantially especially after the second quake. Selwyn district shows similar hot-spot activity before and after the first quake even in TC1 zones, however, there is differentiation in the homogeneity of the hot-spots in one of the two TC1 zones after the second quake. Differentiation in the homogeneity of the hot-spots exists in the Waimakariri district only for one of the TC2 zones with limited differences otherwise.

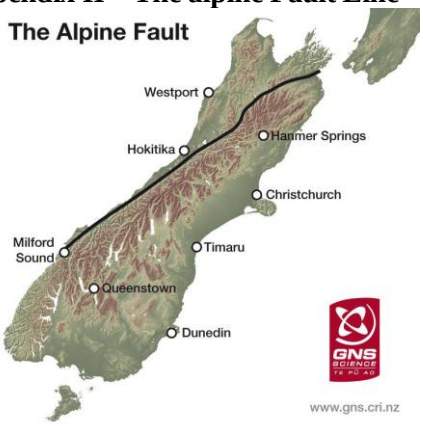
The regression models provided a plethora of evidence regarding the perception of risk through the lens of sale price impact. The models applied indicated significant similarities across all models when accounting for both land zones and districts. Newer houses achieved higher sale prices in all models, both before and after both quakes, but the effect was even higher for TC3 zones. This result shows buyer confidence in newer houses, which are built to conform with updated building codes and therefore decrease the perception of risk especially in TC3 zones. An interesting finding is that sale agreements after either of the two quakes are associated with a price appreciation for the overall dataset as well as TC1 and TC2 zones, however, TC3 experience a sale price decrease after the second quake. This result suggests supply/demand pressures, the possibility of resiliency (sale price increase) or an increased presumption of risk if certain house characteristics (e.g. newer construction etc.) are not met (TC3 zones). Another variable with a statistically significant effect before both quakes was sell days (Time on the Market); although it did not continue after the quakes. Shifting the focus to façade material, fibrolite has a significant negative effect on sale prices of the overall dataset as well as the TC1 zone and TC3 zones. In contrast, mixture and roughcast have a positive effect on sale prices in the overall dataset as well as the TC1 and TC2 zones after both quakes but in some cases before the quakes too. Other material, such as wood, has a positive effect on sale prices although only for the overall dataset and TC2 zones. Among the studied roof materials only tile has a more consistent negative effect on sale prices for the overall dataset and TC2. The more in depth analysis of each of the three districts and their land zones suggests the existence of some differences with the most prominent being the absence of any significance among the roof façade materials for the Selwyn and Waimakariri districts.

In conclusion, the results indicate that with the recent earthquake experience, residents are demonstrating risk mitigation behaviors through an aversion to (paying lower prices for) TC3 zoned property that are regarded to be a higher risk for future liquefaction. However, the quality of the house can overcome the media stigma attached to the TC3 zones. The outcomes of this research will be of interest not only to home owners wanting to know how their home's value has been impacted by market perceptions toward earthquake and liquefaction damage, particularly in the worst affected areas, but also the Rating Valuers tasked with assessing property values for rating purposes.

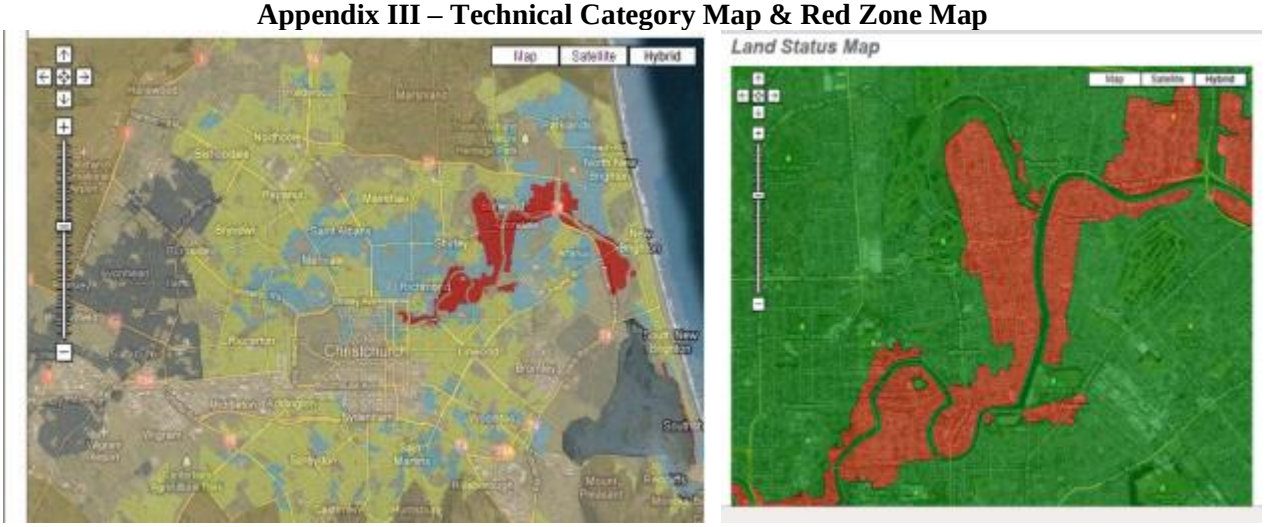
Appendix I – Quake Locations



Appendix II – The alpine Fault Line



Appendix III – Technical Category Map & Red Zone Map



Source: http://cera.govt.nz/sites/cera.govt.nz/files/common/dbh-residential-foundation-technical-categories-20120323.pdf

Key: TC1 – grey; TC2 – yellow; TC3 – blue,

Red - The land that has been so badly damaged it is unlikely it can be rebuilt on.

Appendix IV – Descriptive statistics

Table 1. Overall data descriptive statistics

Agreement Before quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	5026	397,273	225,728
Sale_Price	5147	400,269	216,288
Const. Year	4975	1,966	28
#bedrooms	5146	3.18	1.16
Sell_Days	4601	46.68	60.24
Land area	4184	772.65	543.80

Agreement Before quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	6531	396,052	224,305
Sale_Price	6,693	399,446	217,558
Const. Year	6463	1,966	28
#bedrooms	6692	3.19	1.13
Sell_Days	6016	49.05	60.36
Land area	5424	773.65	551.82

T-tests before vs. after quake Sept. 4th 2010

Variable	t-test result
Valuation	2.32
Sale_Price	-3.65
Const. Year	-8.60
#bedrooms	-3.06
Sell_Days	-3.65
Land area	-0.90

T-tests before vs. after quake Feb. 22nd 2011

Variable	t-test result
Valuation	2.37
Sale_Price	-5.23
Const. Year	-9.96
#bedrooms	-2.87
Sell_Days	-0.81
Land area	-0.93

The difference of means in variable(x) before vs. after quake Sept. 4th 2010 or Feb. 22nd 2011 is more than 0

Agreement After quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	7037	387,962	204,727
Sale_Price	7232	414,417	207,252
Const. Year	6970	1,970	28
#bedrooms	7232	3.24	1.04
Sell_Days	6791	51.57	82.53
Land area	5828	783.38	647.41

Agreement After quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	5532	386,871	200,525
Sale_Price	5,686	419,233	202,874
Const. Year	5482	1,971	28
#bedrooms	5686	3.24	1.04
Sell_Days	5376	50.20	87.42
Land area	4588	785.11	664.90

Agreement Before quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	17	301,529
Brick	1669	412,825
Concrete	1097	341,698
Fibrolite	129	315,357
Glass	3	419,333
Iron	7	423,143
Malthoid	5	574,000
Mixture	246	463,792
N/A	55	429,889
Plastic	10	373,930
Roughcast	626	483,893
Stone	64	521,144
Tile	1	330,000
Unspecified	107	388,851
Wood	1114	381,939

Agreement Before quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	25	303,820
Brick	2198	410,430
Concrete	1413	340,492
Fibrolite	166	315,301
Glass	3	419,333
Iron	12	447,500
Malthoid	2	574,000
Mixture	315	465,996
N/A	75	423,315
Plastic	16	388,613
Roughcast	798	483,017
Stone	82	511,468
Tile	1	330,000
Unspecifie	140	394,154
Wood	1447	383,473

Agreement Before quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	11	423,955
Brick	1	361,000
Concrete	3	1,505,667
Concrete/	1	390,000
Fibrolite	53	280,925
Iron	2745	407,604
Malthoid	28	632,843
Mixture	27	452,537
N/A	55	429,889
Plastic	2	910,800
Roughcast	2	529,250
Stone	5	748,800
Tile	2104	386,633
Unspecifie	110	389,182

Agreement Before quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	20	373,850
Brick	1	361,000
Concrete	4	1,231,750
Concrete/	1	390,000
Fibrolite	67	299,918
Iron	3585	407,886
Malthoid	36	632,183
Mixture	35	465,843
N/A	75	423,315
Plastic	2	910,800
Roughcast	2	529,250
Stone	5	748,800
Tile	2717	384,303
Unspecifie	143	394,297

studied further highlighted in yellow

Agreement Before quake Sept. 4th 2010 in TC1

Variable	#observ.	Average	st. dev.
Valuation	791	385,596	142,672
Sale_Price	810	382,299	138,687
Const. Year	789	1,971	19
#bedrooms	810	3.27	1.26
Sell_Days	739	42.07	50.50

Agreement Before quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	1034	382,443	139,801
Sale_Price	1060	380,387	136,202
Const. Year	1032	1,971	19
#bedrooms	1060	3.25	1.22
Sell_Days	971	44.29	52.44

T-tests before vs. after quake Sept. 4th 2010 - TC1

Variable	t-test result
Valuation	1.86
Sale_Price	-2.15
Const. Year	-1.82
#bedrooms	0.04
Sell_Days	-0.68

T-tests before vs. after quake Feb. 22nd 2011 - TC1

Variable	t-test result
Valuation	1.35
Sale_Price	-3.44
Const. Year	-2.28
#bedrooms	-0.45
Sell_Days	1.01

Agreement After quake Sept. 4th 2010 in TC1

Variable	#observ.	Average	st. dev.
Valuation	1290	374,019	129,401
Sale_Price	1322	395,215	128,501
Const. Year	1286	1,972	20
#bedrooms	1322	3.26	1.05
Sell_Days	1259	43.68	52.44

Agreement After quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	1047	374,445	129,376
Sale_Price	1072	400,118	128,208
Const. Year	1043	1,973	21
#bedrooms	1072	3.28	1.05
Sell_Days	1027	41.95	51.05

Agreement After quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	21	289,370
Brick	2693	426,901
Concrete	1493	350,073
Fibrolite	168	329,307
Glass	8	370,250
Iron	13	424,192
Malthoid	1	850,000
Mixture	340	481,029
N/A	96	425,565
Plastic	21	445,619
Roughcast	847	520,600
Stone	80	517,427
Tile		
Unspecifie	173	425,654
Wood	1276	378,995

Agreement After quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	13	277,483
Brick	2164	432,774
Concrete	1177	353,770
Fibrolite	131	333,317
Glass	8	370,250
Iron	8	388,313
Malthoid	1	850,000
Mixture	271	482,856
N/A	76	430,915
Plastic	15	458,633
Roughcast	675	530,989
Stone	62	529,145
Tile		
Unspecifie	140	429,026
Wood	943	375,601

Agreement After quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	17	369,177
Concrete	8	475,142
Concrete/	1	415,000
Fibrolite	62	383,123
Glass	2	541,500
Iron	3928	423,363
Malthoid	33	777,508
Mixture	41	427,891
N/A	96	425,565
Roughcast	1	430,000
Stone	1	595,000
Tile	2862	397,068
Unspecifie	175	424,516
Wood	3	764,333

Agreement After quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	8	432,813
Concrete	7	484,448
Concrete/	1	415,000
Fibrolite	48	386,419
Glass	2	541,500
Iron	3088	427,322
Malthoid	25	824,750
Mixture	33	407,804
N/A	76	430,915
Roughcast	1	430,000
Stone	1	595,000
Tile	2249	402,727
Unspecifie	142	427,577
Wood	3	764,333

Agreement Before quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	2504	384,062	194,151
Sale_Price	2563	384,017	187,992
Const. Year	2483	1,962	29
#bedrooms	2563	3.16	1.10
Sell_Days	2331	44.61	63.08

Agreement Before quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3265	381,966	186,250
Sale_Price	3346	383,124	188,387
Const. Year	3237	1,962	29
#bedrooms	3346	3.17	1.07
Sell_Days	3060	46.78	60.61

T-tests before vs. after quake Sept. 4th 2010 - TC2

Variable	t-test result
Valuation	-0.67
Sale_Price	-5.06
Const. Year	-6.11
#bedrooms	-1.43
Sell_Days	-1.73

T-tests before vs. after quake Feb. 22nd 2011 - TC2

Variable	t-test result
Valuation	-1.73
Sale_Price	-6.70
Const. Year	-7.31
#bedrooms	-1.67
Sell_Days	0.14

Agreement After quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3663	387,448	197,912
Sale_Price	3756	409,547	209,562
Const. Year	3633	1,966	29
#bedrooms	3756	3.20	1.00
Sell_Days	3545	47.97	85.54

Agreement After quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	2902	390,695	207,131
Sale_Price	2973	417,276	213,833
Const. Year	2879	1,967	29
#bedrooms	2973	3.21	1.01
Sell_Days	2816	46.48	92.30

Agreement Before quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	847	425,123	337,697
Sale_Price	867	427,213	336,237
Const. Year	839	1,959	29
#bedrooms	867	3.11	1.15
Sell_Days	773	44.35	48.74

Agreement Before quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	1055	428,933	347,137
Sale_Price	1079	429,081	345,683
Const. Year	1046	1,959	29
#bedrooms	1079	3.13	1.13
Sell_Days	965	46.64	51.97

T-tests before vs. after quake Sept. 4th 2010 - TC3

Variable	t-test result
Valuation	-0.57
Sale_Price	-0.43
Const. Year	-0.25
#bedrooms	-1.75
Sell_Days	-3.09

T-tests before vs. after quake Feb. 22nd 2011 - TC3

Variable	t-test result
Valuation	-0.07
Sale_Price	-0.25
Const. Year	-0.26
#bedrooms	-1.35
Sell_Days	-1.84

Agreement After quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	635	434,866	317,362
Sale_Price	650	434,638	333,853
Const. Year	635	1,959	31
#bedrooms	650	3.20	0.97
Sell_Days	602	54.16	64.89

Agreement After quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	427	430,199	279,820
Sale_Price	438	433,631	307,935
Const. Year	428	1,959	31
#bedrooms	438	3.20	0.93
Sell_Days	410	53.36	65.98

Table 2. Christchurch descriptive statistics

Agreement Before quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	4254	410,526	236,382
Sale_Price	4345	406,933	229,905
Const. Year	4213	1,963	27
#bedrooms	4345	3.18	1.14
Sell_Days	3937	44.55	58.74
Land area	3502	725.27	343.90

Agreement Before quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	5,491	409,526	235,528
Sale_Price	5615	406,027	232,064
Const. Year	5438	1,963	27
#bedrooms	5615	3.19	1.11
Sell_Days	5112	46.57	57.80
Land area	4509	726.82	388.38

T-tests before vs. after quake Sept. 4th 2010

Variable	t-test result
Valuation	1.046
Sale_Price	-2.47
Const. Year	-6.34
#bedrooms	-1.87
Sell_Days	-3.00
Land area	1.97

T-tests before vs. after quake Feb. 22nd 2011

Variable	t-test result
Valuation	0.8793
Sale_Price	-3.68
Const. Year	-7.48
#bedrooms	-1.79
Sell_Days	-0.65
Land area	3.07

The differrence of means in variable(x) before vs. after quake Sept. 4th 2010 or Feb. 22nd 2011 is more than 0

Agreement After quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	5464	405,640	217,806
Sale_Price	5601	418,333	225,849
Const. Year	5421	1,966	27
#bedrooms	5601	3.22	1.02
Sell_Days	5286	48.85	78.70
Land area	4447	709.53	364.57

Agreement After quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	4,227	405,510	213,303
Sale_Price	4331	422,849	221,555
Const. Year	4196	1,967	27
#bedrooms	4331	3.23	1.02
Sell_Days	4111	47.57	84.40
Land area	3440	702.90	307.11

Agreement Before quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	16	305,750
Brick	1241	418,977
Concrete	975	347,676
Fibrolite	101	330,987
Glass	2	455,000
Iron	6	437,000
Malthoid	2	574,000
Mixture	221	473,276
N/A	29	494,083
Plastic	9	387,778
Roughcast	543	498,165
Stone	46	585,667
Tile	1	330,000
Unspecified	96	386,037
Wood	1057	386,889

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	24	306,729
Brick	1616	415,523
Concrete	1241	347,094
Fibrolite	133	329,441
Glass	2	455,000
Iron	9	504,111
Malthoid	2	574,000
Mixture	283	476,465
N/A	43	471,661
Plastic	15	397,900
Roughcast	698	495,500
Stone	59	573,506
Tile	1	330,000
Unspecifie	124	392,851
Wood	1365	388,288

Agreement Before quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	9	430,389
Concrete	3	1,505,667
Fibrolite	46	289,750
Iron	2242	417,088
Malthoid	28	632,843
Mixture	24	448,979
N/A	29	494,083
Plastic	2	910,800
Roughcast	2	529,250
Stone	4	718,500
Tile	1859	390,258
Unspecifie	97	383,789

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	17	383,824
Concrete	3	1,505,667
Fibrolite	58	307,328
Iron	2904	417,963
Malthoid	36	632,183
Mixture	30	468,800
N/A	43	471,661
Plastic	2	910,800
Roughcast	2	529,250
Stone	4	718,500
Tile	2391	387,065
Unspecifie	125	391,052

Agreement Before quake Sept. 4th 2010 in TC

Variable	#observ.	Average	st. dev.
Valuation	725	379,477	142,442
Sale_Price	739	374,372	137,543
Const. Year	723	1,969	18
#bedrooms	739	3	1
Sell_Days	681	41.44	47.75

Agreement Before quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	944	375,145	139,335
Sale_Price	964	370,989	134,169
Const. Year	942	1,969	18
#bedrooms	964	3	1
Sell_Days	893	43.49	49.07

T-tests before vs. after quake Sept. 4th 2010 - TC1

Variable	t-test result
Valuation	1.94
Sale_Price	-1.40
Const. Year	-1.63
#bedrooms	0.10
Sell_Days	-0.50

T-tests before vs. after quake Feb. 22nd 2011 - TC1

Variable	t-test result
Valuation	1.11
Sale_Price	-2.99
Const. Year	-2.47
#bedrooms	-0.37
Sell_Days	1.12

Agreement After quake Sept. 4th 2010 in TC1

Variable	#observ.	Average	st. dev.
Valuation	1160	366,894	127,869
Sale_Price	1190	382,965	121,143
Const. Year	1159	1,971	20
#bedrooms	1190	3	1
Sell_Days	1139	42.61	50.22

Agreement After quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	941	368,312	127,917
Sale_Price	965	388,347	120,355
Const. Year	940	1,971	20
#bedrooms	965	3	1
Sell_Days	927	40.90	49.51

Agreement After quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	17	289,104
Brick	1804	426,327
Concrete	1239	357,860
Fibrolite	128	334,520
Glass	6	313,167
Iron	8	420,375
Malthoid	1	850,000
Mixture	288	490,865
N/A	53	454,453
Plastic	19	450,737
Roughcast	715	532,163
Stone	58	567,986
Unspecified	127	418,729
Wood	1137	383,313

Agreement After quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	9	271,697
Brick	1429	432,161
Concrete	973	361,385
Fibrolite	96	337,838
Glass	6	313,167
Iron	5	289,600
Malthoid	1	850,000
Mixture	226	491,698
N/A	39	464,949
Plastic	13	468,115
Roughcast	560	544,896
Stone	45	578,822
Unspecifie	99	419,440
Wood	829	379,680

Agreement After quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	15	385,933
Fibrolite	58	387,011
Iron	2878	432,946
Malthoid	33	777,508
Mixture	37	430,799
N/A	53	454,453
Roughcast	1	430,000
Tile	2395	395,379
Unspecifie	127	418,729
Wood	3	764,333

Agreement After quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	7	448,214
Fibrolite	46	390,220
Iron	2216	436,537
Malthoid	25	824,750
Mixture	31	408,098
N/A	39	464,949
Roughcast	1	430,000
Tile	1863	400,938
Unspecifie	99	419,440
Wood	3	764,333

Agreement Before quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	2390	389,799	194,981
Sale_Price	2446	387,172	190,542
Const. Year	2370	1,961	29
#bedrooms	2446	3	1
Sell_Days	2226	44.49	63.74

Agreement Before quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3121	387,494	186,784
Sale_Price	3199	386,253	190,890
Const. Year	3094	1,961	29
#bedrooms	3199	3	1
Sell_Days	2925	46.53	61.11

T-tests before vs. after quake Sept. 4th 2010 -

Variable	t-test result
Valuation	-1.01
Sale_Price	-4.88
Const. Year	-5.57
#bedrooms	-1.45
Sell_Days	-2.04

T-tests before vs. after quake Feb. 22nd 2011 -

Variable	t-test result
Valuation	-2.23
Sale_Price	-6.48
Const. Year	-6.56
#bedrooms	-1.62
Sell_Days	-0.43

Agreement After quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3428	395,078	199,835
Sale_Price	3515	412,978	214,724
Const. Year	3395	1,965	29
#bedrooms	3515	3	1
Sell_Days	3315	48.64	87.74

Agreement After quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	2697	399,176	209,801
Sale_Price	2762	421,079	219,824
Const. Year	2671	1,966	29
#bedrooms	2762	3	1
Sell_Days	2616	47.47	95.11

Agreement Before quake Sept. 4th 2010 in TC

Variable	#observ.	Average	st. dev.
Valuation	833	428,555	339,181
Sale_Price	851	429,235	338,771
Const. Year	825	1,959	29
#bedrooms	851	3	1
Sell_Days	758	44.15	48.43

Agreement Before quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	1040	431,698	348,555
Sale_Price	1062	430,686	347,951
Const. Year	1031	1,959	29
#bedrooms	1062	3	1
Sell_Days	950	46.52	51.80

T-tests before vs. after quake Sept. 4th 2010 -

Variable	t-test result
Valuation	-0.55
Sale_Price	-0.41
Const. Year	-0.33
#bedrooms	-1.74
Sell_Days	-3.07

T-tests before vs. after quake Feb. 22nd 2011 -

Variable	t-test result
Valuation	-0.20
Sale_Price	-0.31
Const. Year	-0.22
#bedrooms	-1.30
Sell_Days	-1.76

Agreement After quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	623	438,187	319,135
Sale_Price	637	436,501	336,497
Const. Year	622	1,959	31
#bedrooms	637	3	1
Sell_Days	590	53.98	65.00

Agreement After quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	416	435,123	281,416
Sale_Price	426	436,483	311,048
Const. Year	416	1,959	31
#bedrooms	426	3	1
Sell_Days	398	53.06	66.17

Table 3. Selwyn descriptive statistics

Agreement Before quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	276	412,794	104,213
Sale_Price	292	427,157	111,830
Const. Year	275	1,994	14.52
#bedrooms	292	3.47	1.29
Sell_Days	246	64	80.62
Land area	272	1,243	1,403.29

Agreement Before quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	379	408,810	104,685
Sale_Price	398	426,846	108,335
Const. Yea	374	1,993.96	14.51
#bedrooms	398	3.51	1.24
Sell_Days	337	64.05	78.70
Land area	372	1,217.83	1,320.03

T-tests before vs. after quake Sept. 4th 2010

Variable	t-test result
Valuation	0.86
Sale_Price	-4.78
Const. Year	-0.23
#bedrooms	-1.52
Sell_Days	2.78
Land area	0.06

T-tests before vs. after quake Feb. 22nd 2011

Variable	t-test result
Valuation	0.14
Sale_Price	-6.18
Const. Year	-0.31
#bedrooms	-1.19
Sell_Days	3.92
Land area	-0.44

The differrence of means in variable(x) before vs. after quake Sept. 4th 2010 or Feb. 22nd 2011 is more than 0

Agreement Before quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Brick	203	428,408
Concrete	18	358,944
Fibrolite	3	269,167
Glass	1	348,000
Mixture	8	487,000
N/A	14	396,036
Roughcast	30	454,647
Stone	4	575,125
Unspecifie	5	438,500
Wood	6	428,917

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Brick	281	428,723
Concrete	27	347,972
Fibrolite	3	269,167
Glass	1	348,000
Mixture	10	476,850
N/A	16	410,875
Roughcast	36	464,289
Stone	5	555,100
Unspecifie	6	430,500
Wood	11	416,955

Agreement Before quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Brick	1	361,000
ConcreteT	1	390,000
Iron	174	435,845
Mixture	3	481,000
N/A	14	396,036
Stone	1	870,000
Tile	91	407,218
Unspecifie	7	461,071

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Brick	1	361,000
ConcreteT	1	390,000
Iron	241	433,387
Mixture	4	503,875
N/A	16	410,875
Stone	1	870,000
Tile	124	409,265
Unspecifie	10	447,900

Agreement After quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	536	405,862	117,027
Sale_Price	559	467,239	124,237
Const. Year	517	1,994	15.29
#bedrooms	559	3.61	1.16
Sell_Days	506	48	60.86
Land area	515	1,237	1,181.05

Agreement After quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	433	407,700	119,602
Sale_Price	453	476,891	127,692
Const. Yea	418	1,994.28	15.47
#bedrooms	453	3.61	1.19
Sell_Days	415	43.96	57.17
Land area	415	1,257.48	1,207.73

Agreement Before quake Sept. 4th 2010 in TC1

Variable	#observ.	Average	st. dev.
Valuation	66	452,803	128,051
Sale_Price	71	464,804	123,584
Const. Year	66	1,989	20
#bedrooms	71	3	1
Sell_Days	58	49	75.92

Agreement Before quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	90	459,000	121,035
Sale_Price	96	474,756	120,086
Const. Yea	90	1,990	18
#bedrooms	96	3	1
Sell_Days	78	53.36	81.54

T-tests before vs. after quake Sept. 4th 2010 - TC1

Variable	t-test result
Valuation	0.79
Sale_Price	-2.14
Const. Year	-0.04
#bedrooms	0.01
Sell_Days	-0.37

T-tests before vs. after quake Feb. 22nd 2011 - TC1

Variable	t-test result
Valuation	1.68
Sale_Price	-1.68
Const. Year	0.73
#bedrooms	-0.19
Sell_Days	0.15

Agreement After quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	3	290,667
Brick	380	465,125
Concrete	39	371,455
Fibrolite	4	390,500
Glass	1	738,000
Iron	2	484,250
Mixture	10	504,995
N/A	18	471,889
Plastic	2	397,000
Roughcast	46	553,935
Stone	3	629,000
Unspecifie	27	491,944
Wood	24	450,979

Agreement After quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	3	290,667
Brick	302	474,316
Concrete	30	385,083
Fibrolite	4	390,500
Glass	1	738,000
Iron	2	484,250
Mixture	8	522,181
N/A	16	466,531
Plastic	2	397,000
Roughcast	40	560,150
Stone	2	706,000
Unspecifie	24	501,292
Wood	19	463,711

Agreement After quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Glass	1	738,000
Iron	328	464,163
Mixture	3	459,667
N/A	18	471,889
Tile	181	467,596
Unspecifie	28	489,116

Agreement After quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Glass	1	738,000
Iron	261	473,702
Mixture	2	403,250
N/A	16	466,531
Tile	148	479,344
Unspecifie	25	497,750

Agreement After quake Sept. 4th 2010 in TC1

Variable	#observ.	Average	st. dev.
Valuation	130	437,592	126,046
Sale_Price	132	505,657	140,200
Const. Year	127	1,989	21
#bedrooms	132	3	1
Sell_Days	120	54	69.60

Agreement After quake Feb. 22nd 2011 in TC1

Variable	#observ.	Average	st. dev.
Valuation	106	428,887	130,109
Sale_Price	107	506,273	147,331
Const. Yea	103	1,988	22
#bedrooms	107	3	1
Sell_Days	100	51.66	63.07

Agreement Before quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3	460,000	200,749
Sale_Price	3	516,500	236,874
Const. Year	3	1,947	23
#bedrooms	3	4	1
Sell_Days	3	57	38.73

Agreement Before quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	3	460,000	200,749
Sale_Price	3	516,500	236,874
Const. Yea	3	1,947	23
#bedrooms	3	4	1
Sell_Days	3	56.67	38.73

Agreement Before quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	1	560,000	
Sale_Price	1	615,000	
Const. Year	1	2,000	
#bedrooms	1	5	
Sell_Days	1	10	

Agreement Before quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	2	512,500	67,175
Sale_Price	2	545,000	98,995
Const. Yea	2	1,955	64
#bedrooms	2	4	1
Sell_Days	1	10.00	

Agreement After quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	10	504,000	148,302
Sale_Price	11	536,336	124,427
Const. Year	11	1,969	29
#bedrooms	11	3	2
Sell_Days	10	43	34.38

Agreement After quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	10	504,000	148,302
Sale_Price	11	536,336	124,427
Const. Yea	11	1,969	29
#bedrooms	11	3	2
Sell_Days	10	43.10	34.38

Agreement After quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	2	482,500	24,749
Sale_Price	3	560,000	99,875
Const. Year	3	1,940	52
#bedrooms	3	4	1
Sell_Days	2	53	0.00

Agreement After quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	1	500,000	
Sale_Price	2	602,500	95,459
Const. Yea	2	1,955	64
#bedrooms	2	4	
Sell_Days	2	53.00	0.00

TC2 & TC3 ttests were not done because of limited observations

Table 4. Waimakariri descriptive statistics

Agreement Before quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	496	274,968	120,425
Sale_Price	510	328,104	93,238
Const. Year	487	1,978	25
#bedrooms	509	2.97	1.21
Sell_Days	418	56.63	57.61
Land area	410	865.47	729.66

Agreement Before quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	661	276,805	119,293
Sale_Price	680	329,065	92,733
Const. Year	651	1,978	26
#bedrooms	679	3.00	1.17
Sell_Days	567	62.54	67.18
Land area	543	858.24	662.29

T-tests before vs. after quake Sept. 4th 2010

Variable	t-test result
Valuation	-1.60
Sale_Price	-7.28
Const. Yea	-1.38
#bedrooms	-2.58
Sell_Days	-2.57
Land area	-0.54

T-tests before vs. after quake Feb. 22nd 2011

Variable	t-test result
Valuation	-1.50
Sale_Price	-8.66
Const. Year	-1.85
#bedrooms	-2.61
Sell_Days	-0.73
Land area	-0.88

The differrence of means in variable(x) before vs. after quake Sept. 4th 2010 or Feb. 22nd 2011 is more than 0

Agreement Before quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	1	234,000
Brick	225	364,838
Concrete	104	282,669
Fibrolite	25	257,753
Iron	1	340,000
Mixture	17	329,577
N/A	12	314,250
Plastic	1	249,300
Roughcast	53	354,226
Stone	14	293,714
Unspecifie	6	392,500
Wood	51	273,822

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	1	234,000
Brick	301	366,010
Concrete	145	282,593
Fibrolite	30	257,228
Iron	3	277,667
Mixture	22	326,400
N/A	16	305,827
Plastic	1	249,300
Roughcast	64	357,414
Stone	18	296,000
Unspecifie	8	378,000
Wood	71	285,710

Agreement Before quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	2	395,000
Fibrolite	7	222,929
Iron	329	328,043
N/A	12	314,250
Tile	154	330,716
Unspecifie	6	392,500

studied further highlighted in yellow

Agreement Before quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	3	317,333
Concrete	1	410,000
Fibrolite	9	252,167
Iron	440	327,412
Mixture	1	225,000
N/A	16	305,827
Tile	202	336,282
Unspecifie	8	378,000

Agreement After quake Sept. 4th 2010

Variable	#observ.	Average	st. dev.
Valuation	1037	285,564	122,941
Sale_Price	1072	366,415	106,828
Const. Year	1032	1,980	25
#bedrooms	1072	3.13	1.03
Sell_Days	999	67.94	106.54
Land area	866	893.11	1,071.95

Agreement After quake Feb. 22nd 2011

Variable	#observ.	Average	st. dev.
Valuation	872	286,177	124,264
Sale_Price	902	372,912	108,313
Const. Year	868	1,980	25
#bedrooms	902	3.14	1.03
Sell_Days	850	65.98	109.57
Land area	733	903.48	1,153.24

Agreement After quake Sept. 4th 2010 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	1	290,000
Brick	509	400,400
Concrete	215	301,324
Fibrolite	35	303,974
Glass	1	345,000
Iron	3	394,333
Mixture	42	407,877
N/A	25	330,969
Roughcast	86	406,629
Stone	19	345,474
Unspecifie	19	377,738
Wood	115	321,279

Agreement After quake Feb. 22nd 2011 - exterior_d_ValBiz_

	#observ.	Average sale_price
Aluminium	1	290,000
Brick	433	405,827
Concrete	174	305,783
Fibrolite	31	311,937
Glass	1	345,000
Iron	1	690,000
Mixture	37	420,347
N/A	21	340,571
Roughcast	75	411,594
Stone	15	356,533
Unspecifie	17	382,825
Wood	95	322,385

Agreement After quake Sept. 4th 2010 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	2	243,500
Concrete	8	475,142
ConcreteT	1	415,000
Fibrolite	4	326,750
Glass	1	345,000
Iron	722	366,626
Mixture	1	225,000
N/A	25	330,969
Stone	1	595,000
Tile	286	366,583
Unspecifie	20	370,826

Agreement After quake Feb. 22nd 2011 - roof_descr_ValBiz_

	#observ.	Average sale_price
Aluminium	1	325,000
Concrete	7	484,448
ConcreteT	1	415,000
Fibrolite	2	299,000
Glass	1	345,000
Iron	611	374,089
N/A	21	340,571
Stone	1	595,000
Tile	238	369,093
Unspecifie	18	374,862

Agreement Before quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	111	258,478	120,542
Sale_Price	114	312,818	94,431
Const. Year	110	1,973	27
#bedrooms	114	3	1
Sell_Days	102	46.89	47.67

Agreement Before quake Feb. 22nd 2011 in TC

Variable	#observ.	Average	st. dev.
Valuation	141	257,929	119,820
Sale_Price	144	310,846	92,807
Const. Year	140	1,973	27
#bedrooms	144	3	1
Sell_Days	132	52.09	48.74

T-tests before vs. after quake Sept. 4th 2010 - TC2

Variable	t-test result
Valuation	-0.55
Sale_Price	-3.63
Const. Yea	-1.56
#bedrooms	-0.56
Sell_Days	1.60

T-tests before vs. after quake Feb. 22nd 2011 - TC2

Variable	t-test result
Valuation	-0.76
Sale_Price	-4.84
Const. Year	-2.13
#bedrooms	-1.06
Sell_Days	3.74

Agreement After quake Sept. 4th 2010 in TC2

Variable	#observ.	Average	st. dev.
Valuation	225	266,022	110,462
Sale_Price	230	351,053	86,858
Const. Year	227	1,978	23
#bedrooms	230	3	1
Sell_Days	220	38.11	41.70

Agreement After quake Feb. 22nd 2011 in TC2

Variable	#observ.	Average	st. dev.
Valuation	195	267,580	109,314
Sale_Price	200	358,208	84,688
Const. Year	197	1,979	22
#bedrooms	200	3	1
Sell_Days	190	33.12	38.25

Agreement Before quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	13	194,846	60,058
Sale_Price	15	300,000	72,414
Const. Year	13	1,967	10
#bedrooms	15	3	1
Sell_Days	14	57.79	64.54

Agreement Before quake Feb. 22nd 2011 in TC

Variable	#observ.	Average	st. dev.
Valuation	13	194,846	60,058
Sale_Price	15	300,000	72,414
Const. Year	13	1,967	10
#bedrooms	15	3	1
Sell_Days	14	57.79	64.54

T-tests before vs. after quake Sept. 4th 2010 - TC3

Variable	t-test result
Valuation	-0.99
Sale_Price	1.03
Const. Yea	-0.01
#bedrooms	-0.19
Sell_Days	-0.28

T-tests before vs. after quake Feb. 22nd 2011 - TC3

Variable	t-test result
Valuation	-0.99
Sale_Price	1.03
Const. Year	-0.01
#bedrooms	-0.19
Sell_Days	-0.28

Agreement After quake Sept. 4th 2010 in TC3

Variable	#observ.	Average	st. dev.
Valuation	10	218,400	53,681
Sale_Price	10	278,350	30,235
Const. Year	10	1,967	23
#bedrooms	10	3	1
Sell_Days	10	65.50	67.49

Agreement After quake Feb. 22nd 2011 in TC3

Variable	#observ.	Average	st. dev.
Valuation	10	218,400	53,681
Sale_Price	10	278,350	30,235
Const. Year	10	1,967	23
#bedrooms	10	3	1
Sell_Days	10	65.50	67.49

Appendix V – Hot-spot analysis

Figure 5. Christchurch valuation hot-spots before and after the 9/4/10 and the 2/22/11 earthquakes

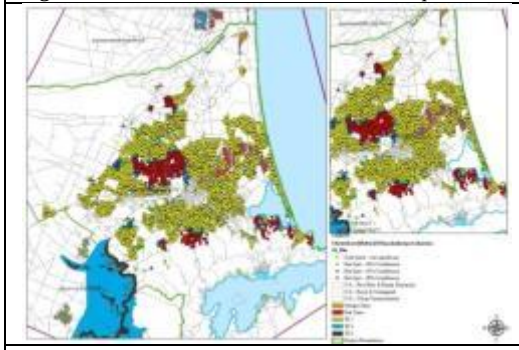
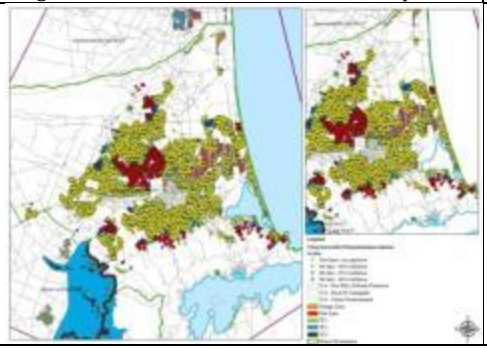
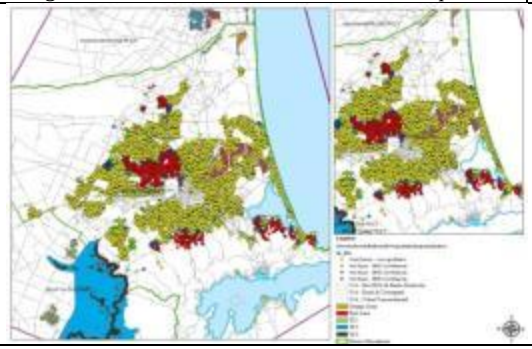
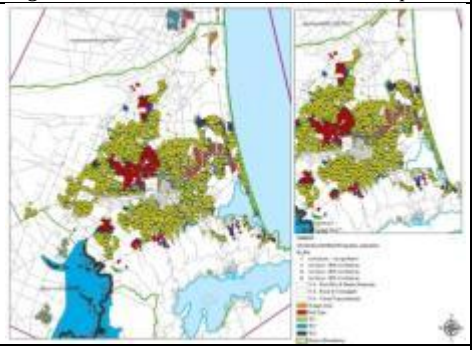
Figure 5a. Houses sold before the 9/4/10 quake	Figure 5b. Houses sold after the 9/4/10 quake	Figure 5c. Houses sold before the 2/22/11 quake	Figure 5d. Houses sold after the 2/22/11quake
			

Figure 6. Selwyn valuation hot-spots before and after the 9/4/10 and the 2/22/11 earthquakes

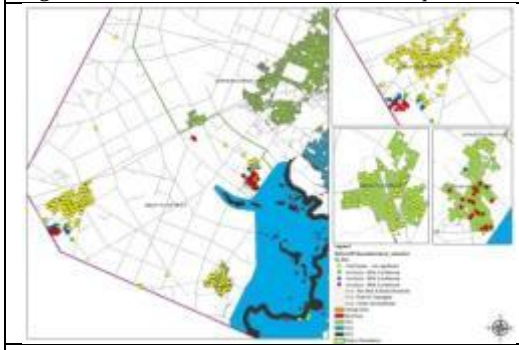
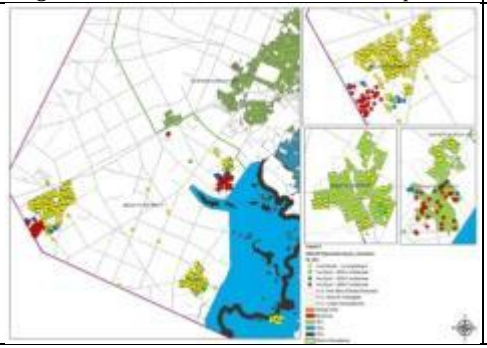
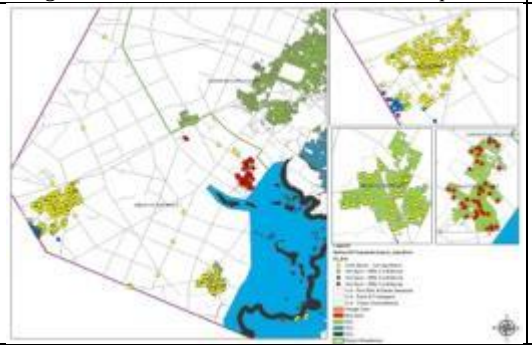
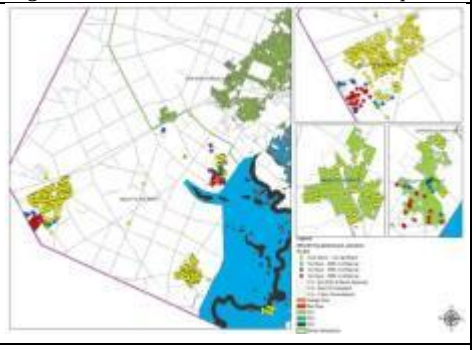
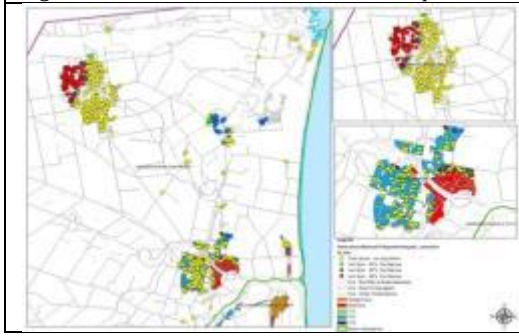
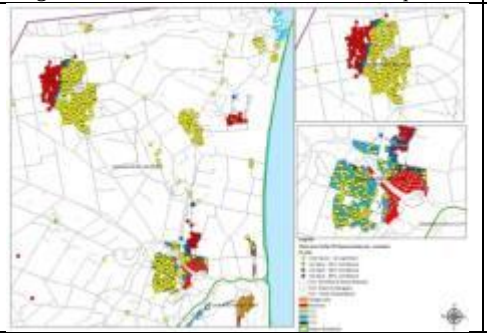
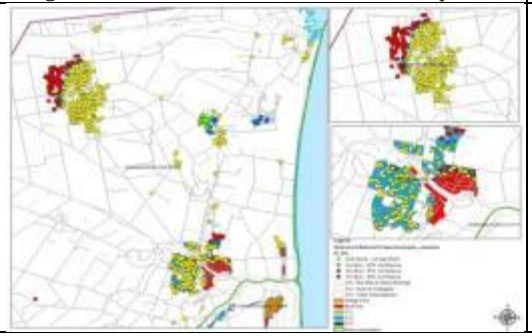
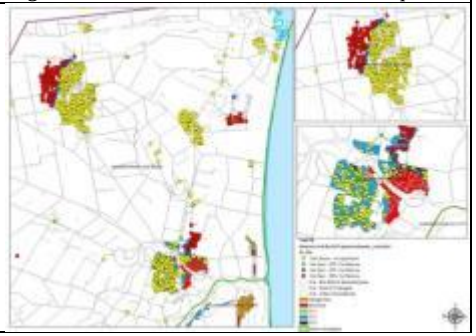
Figure 6a. Houses sold before the 9/4/10 quake	Figure 6b. Houses sold after the 9/4/10 quake	Figure 6c. Houses sold before the 2/22/11 quake	Figure 6d. Houses sold after the 2/22/11quake
			

Figure 7. Waimakariri valuation hot-spots before and after the 9/4/10 and the 2/22/11 earthquakes

Figure 7a. Houses sold before the 9/4/10 quake	Figure 7b. Houses sold after the 9/4/10 quake	Figure 7c. Houses sold before the 2/22/11 quake	Figure 7d. Houses sold after the 2/22/11quake
			

Appendix VI – Hedonic modeling

Table 5.Assessment of the effect of the two major earthquakes on the sale prices of the overall dataset and those in areas designated as TC1

	Overall data				Area designation: TC1			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Before 9/4/10 quake	After 9/4/10 quake	Before 2/22/11 quake	After 2/22/11 quake	Before 9/4/10 quake	After 9/4/10 quake	Before 2/22/11 quake	After 2/22/11 quake
Const.Year	0.00463***	0.00491***	0.00451***	0.00511***	0.00639***	0.00569***	0.00627***	0.00564***
	(16.14)	(22.55)	(18.22)	(20.85)	(10.03)	(15.16)	(11.56)	(14.12)
Bedrooms	0.152***	0.143***	0.153***	0.138***	0.118***	0.110***	0.121***	0.103***
	(16.93)	(20.72)	(19.81)	(18.27)	(7.23)	(12.11)	(9.79)	(10.15)
Agr.Year	-0.0190	0.0416***	-0.0173*	0.0436***	-0.0540**	0.0493***	-0.0361*	0.0573***
	(-1.92)	(6.95)	(-2.25)	(4.95)	(-2.84)	(5.40)	(-2.56)	(4.17)
Sell_days	-0.000217*	-0.000105	-0.000191*	-0.0000925	-0.000225	-0.000172	-0.000223	-0.000130
	(-2.04)	(-1.05)	(-2.00)	(-0.81)	(-1.35)	(-1.20)	(-1.65)	(-0.75)
Land_area	0.000153***	0.000103***	0.000145***	0.0000980***	0.000230***	0.000345***	0.000243***	0.000363***
	(3.85)	(4.23)	(4.67)	(3.73)	(3.53)	(9.24)	(5.06)	(7.80)
Exterior Façade Material								
Brick	0.0579	0.00559	0.0534	-0.00529	-0.0638	0.0913*	0.0359	0.0680
	(1.25)	(0.17)	(1.27)	(-0.15)	(-0.50)	(2.00)	(0.31)	(1.49)
Concrete	-0.00688	-0.0569	-0.0158	-0.0626	-0.113	0.0270	-0.0200	0.00483
	(-0.15)	(-1.71)	(-0.38)	(-1.81)	(-0.88)	(0.59)	(-0.18)	(0.11)
Fibrolite	-0.0735	-0.113**	-0.0871	-0.110**	-0.383**	-0.145*	-0.239	-0.195***
	(-1.35)	(-2.88)	(-1.78)	(-2.69)	(-2.66)	(-2.56)	(-1.88)	(-3.42)
Mixture	0.168**	0.138***	0.165***	0.129**	0.0288	0.145*	0.101	0.137*
	(3.27)	(3.60)	(3.52)	(3.24)	(0.22)	(2.44)	(0.87)	(2.21)
Roughcast	0.171***	0.164***	0.165***	0.165***	0.0274	0.173***	0.141	0.131*
	(3.54)	(4.64)	(3.78)	(4.45)	(0.20)	(3.36)	(1.18)	(2.49)
Stone	0.0853	0.120*	0.0794	0.127	0.0331	0.183	0.133	0.159
	(1.29)	(1.97)	(1.23)	(1.96)	(0.16)	(1.89)	(0.70)	(1.63)
Wood	0.178***	0.116***	0.165***	0.109**	-0.167	-0.0488	-0.0672	-0.0835
	(3.69)	(3.32)	(3.82)	(2.95)	(-1.27)	(-1.01)	(-0.58)	(-1.68)
Roof Façade Material								
Fibrolite	-0.125*	-0.134*	-0.103	-0.162*	0	-0.00992	0.0640**	0
	(-2.32)	(-2.08)	(-1.92)	(-2.35)	.	(-0.62)	(2.68)	.
Malthoid	0.193*	0.277*	0.129	0.376**	0	0.0631	0	0.0732
	(2.12)	(2.55)	(1.48)	(3.27)	.	(1.03)	.	(1.00)
Mixture	0.0441	-0.0348	0.0506	-0.0550	0.00399	0.0172	0.0977	-0.0117
	(0.57)	(-0.55)	(0.74)	(-0.82)	(0.04)	(0.31)	(0.90)	(-0.20)
Tile	-0.0341***	-0.0210**	-0.0374***	-0.0128	-0.0151	-0.0134	-0.0278	-0.000291
	(-3.42)	(-2.68)	(-4.33)	(-1.47)	(-0.75)	(-1.01)	(-1.61)	(-0.02)
_cons	41.31*	-81.11***	38.01*	-85.48***	108.3**	-98.25***	72.50*	-114.1***
	(2.07)	(-6.73)	(2.46)	(-4.82)	(2.83)	(-5.35)	(2.55)	(-4.12)
N	3722	5416	4844	4294	568	989	753	804
R-sq	0.375	0.409	0.374	0.418	0.510	0.579	0.530	0.562
vif	4.9	3.73	4.47	3.78	8.26	3.15	6.92	3.09

t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001
Iron roof façade was dropped due to multicolinearity

Table 6. Assessment of the effect of the two major earthquakes on the sale prices of the areas designated as TC2 and TC3

	Area designation: TC2				Area designation: TC3			
	(1) Before 9/4/10 quake	(2) After 9/4/10 quake	(3) Before 2/22/11 quake	(4) After 2/22/11 quake	(5) Before 9/4/10 quake	(6) After 9/4/10 quake	(7) Before 2/22/11 quake	(8) After 2/22/11 quake
Const.Year	0.00539***	0.00568***	0.00517***	0.00588***	0.00439***	0.00705***	0.00477***	0.00731***
	(14.84)	(19.13)	(16.20)	(17.78)	(5.22)	(8.07)	(6.45)	(6.65)
Bedrooms	0.139***	0.133***	0.142***	0.129***	0.170***	0.179***	0.155***	0.219***
	(11.65)	(13.70)	(13.03)	(11.94)	(6.72)	(6.28)	(7.03)	(6.24)
Agr.Year	-0.0121	0.0476***	-0.0114	0.0438***	-0.00660	-0.0225	0.00304	-0.101*
	(-0.94)	(5.83)	(-1.18)	(3.53)	(-0.24)	(-0.96)	(0.13)	(-2.30)
Sell_days	-0.000261	-0.000276	-0.000302*	-0.000217	-0.000255	0.000313	0.0000840	0.0000458
	(-1.90)	(-1.56)	(-2.54)	(-1.10)	(-0.65)	(0.72)	(0.20)	(0.09)
Land_area	0.000263**	0.000319***	0.000293***	0.000293***	0.000641***	0.000703***	0.000683***	0.000587***
	(3.01)	(5.65)	(3.36)	(4.91)	(6.87)	(8.13)	(8.73)	(4.23)
Exterior Façade Material								
Brick	0.115	0.0803	0.119*	0.0582	0.0854	-0.436*	-0.0140	-0.475
	(1.88)	(1.41)	(2.39)	(0.86)	(0.89)	(-2.54)	(-0.14)	(-1.94)
Concrete	0.0159	-0.00518	0.0193	-0.0252	-0.0179	-0.485**	-0.112	-0.496*
	(0.26)	(-0.09)	(0.39)	(-0.37)	(-0.19)	(-2.86)	(-1.13)	(-2.03)
Fibrolite	-0.0549	-0.0207	-0.0654	-0.00363	-0.156	-0.510**	-0.242*	-0.520*
	(-0.77)	(-0.31)	(-1.10)	(-0.05)	(-1.45)	(-2.78)	(-2.16)	(-2.05)
Mixture	0.169*	0.206***	0.169**	0.203**	0.323**	-0.143	0.279*	-0.244
	(2.46)	(3.36)	(3.02)	(2.79)	(2.70)	(-0.75)	(2.26)	(-0.93)
Roughcast	0.187**	0.220***	0.175***	0.224**	0.219*	-0.0549	0.153	-0.0727
	(2.96)	(3.82)	(3.40)	(3.29)	(2.12)	(-0.32)	(1.44)	(-0.29)
Stone	0.0679	0.123	0.0622	0.119	0.328	-0.0587	0.213	0.208
	(0.77)	(1.49)	(0.85)	(1.25)	(1.64)	(-0.25)	(1.38)	(0.62)
Wood	0.216***	0.197***	0.209***	0.185**	0.239*	-0.0377	0.167	-0.0189
	(3.41)	(3.40)	(4.04)	(2.66)	(2.42)	(-0.22)	(1.62)	(-0.08)
Roof Façade Material								
Fibrolite	-0.137*	-0.0821	-0.0995	-0.104	-0.0480	-0.590***	-0.0917	-0.574***
	(-2.05)	(-1.12)	(-1.36)	(-1.45)	(-0.45)	(-5.10)	(-0.88)	(-5.05)
Malthoid	0.119	0.387*	0.0368	0.550***	0.286***	0.00915	0.00146	-0.00234
	(1.00)	(2.40)	(0.31)	(4.23)	(3.73)	(0.05)	(0.01)	(-0.01)
Mixture	-0.0144	-0.0342	-0.0206	-0.0448	0.263	-0.254	0.00931	-0.390***
	(-0.15)	(-0.31)	(-0.22)	(-0.42)	(0.86)	(-1.86)	(0.05)	(-6.06)
Tile	-0.0464***	-0.0431***	-0.0477***	-0.0410***	-0.0528	-0.0183	-0.0474	-0.0243
	(-3.52)	(-4.11)	(-4.20)	(-3.43)	(-1.84)	(-0.51)	(-1.87)	(-0.53)
_cons	25.74	-94.72***	24.73	-87.41***	16.36	43.46	-3.662	201.3*
	(1.00)	(-5.76)	(1.28)	(-3.50)	(0.29)	(0.91)	(-0.08)	(2.27)
N	1895	2824	2472	2247	628	486	776	338
R-sq	0.420	0.446	0.421	0.451	0.425	0.492	0.455	0.476
vif	4.41	4.27	4.16	4.53	5.33	5.07	5.17	5.28

t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001

Table 7. Assessment of the effect of the two major earthquakes on the sale prices of the **Christchurch** area (overall & TC1)

	Overall data				Area designation: TC1			
	(1) Before 9/4/10 quake	(2) After 9/4/10 quake	(3) Before 2/22/11 quake	(4) After 2/22/11 quake	(5) Before 9/4/10 quake	(6) After 9/4/10 quake	(7) Before 2/22/11 quake	(8) After 2/22/11 quake
Const.Year	0.00524***	0.00565***	0.00512***	0.00588***	0.00692***	0.00587***	0.00678***	0.00582***
	(16.52)	(21.49)	(18.20)	(21.06)	(9.01)	(14.03)	(10.04)	(13.12)
Bedrooms	0.150***	0.145***	0.151***	0.142***	0.123***	0.122***	0.125***	0.119***
	(15.31)	(18.15)	(17.58)	(16.22)	(7.01)	(12.38)	(8.74)	(10.92)
Agr.Year	-0.0154	0.0376***	-0.0147	0.0271**	-0.0481*	0.0477***	-0.0349*	0.0586***
	(-1.43)	(5.50)	(-1.71)	(2.59)	(-2.29)	(4.85)	(-2.20)	(3.96)
Sell_days	-0.000193	-0.000160	-0.000159	-0.000187	-0.000320	-0.000238	-0.000297	-0.000198
	(-1.55)	(-1.20)	(-1.34)	(-1.22)	(-1.46)	(-1.45)	(-1.67)	(-1.00)
Land_area	0.000308***	0.000237***	0.000248***	0.000290***	0.000351**	0.000405***	0.000334***	0.000425***
	(4.97)	(4.21)	(4.06)	(6.21)	(3.15)	(8.62)	(3.64)	(8.21)
Exterior Façade Material								
Brick	0.0847	0.0294	0.0858	0.00823		0.0931		0.0625
	(1.65)	(0.64)	(1.72)	(0.16)		(1.81)		(1.23)
Concrete	-0.00354	-0.0452	-0.00498	-0.0592	-0.0467*	0.0258	-0.0519*	-0.00282
	(-0.07)	(-0.98)	(-0.10)	(-1.16)	(-1.97)	(0.51)	(-2.55)	(-0.06)
Fibrolite	-0.0555	-0.0821	-0.0665	-0.0746	-0.322***	-0.153*	-0.275***	-0.213***
	(-0.93)	(-1.55)	(-1.17)	(-1.28)	(-4.41)	(-2.43)	(-4.31)	(-3.46)
Mixture	0.176**	0.155**	0.179***	0.139*	0.0966**	0.145*	0.0720*	0.131
	(3.15)	(3.10)	(3.30)	(2.49)	(2.88)	(2.23)	(2.41)	(1.93)
Roughcast	0.186***	0.183***	0.183***	0.182***	0.0932	0.167**	0.111*	0.116*
	(3.51)	(3.81)	(3.55)	(3.46)	(1.73)	(2.93)	(2.49)	(2.04)
Stone	0.133	0.155*	0.149*	0.133	0.0951	0.148	0.0960	0.121
	(1.76)	(2.15)	(2.07)	(1.66)	(0.62)	(1.43)	(0.63)	(1.16)
Wood	0.192***	0.152**	0.185***	0.146**	-0.101**	-0.0496	-0.0998***	-0.0902
	(3.62)	(3.14)	(3.57)	(2.77)	(-2.80)	(-0.91)	(-3.38)	(-1.62)
Roof Façade Material								
Fibrolite	-0.126*	-0.166*	-0.107	-0.205**	0	0.000334	0.0709**	0
	(-2.21)	(-2.57)	(-1.93)	(-2.95)	.	(0.02)	(2.72)	.
Malthoid	0.136	0.239*	0.0857	0.333**	0	0.0519	0	0.0576
	(1.60)	(2.25)	(1.03)	(2.97)	.	(0.89)	.	(0.86)
Mixture	0.0367	-0.0625	0.0361	-0.0825	0.0890*	0.0420	0.202*	0.0196
	(0.42)	(-0.93)	(0.49)	(-1.10)	(2.21)	(0.79)	(2.18)	(0.34)
Tile	-0.0595***	-0.0456***	-0.0600***	-0.0401***	-0.00893	-0.0130	-0.0246	0.00333
	(-5.57)	(-4.94)	(-6.21)	(-3.90)	(-0.41)	(-0.92)	(-1.34)	(0.21)
_cons	32.63	-74.61***	31.66	-53.97*	95.16*	-95.46***	68.95*	-117.2***
	(1.52)	(-5.43)	(1.83)	(-2.56)	(2.25)	(-4.83)	(2.15)	(-3.93)
N	3174	4177	4100	3251	517	880	684	713
R-sq	0.413	0.433	0.404	0.449	0.483	0.543	0.502	0.534
vif	4.95	3.95	4.44	4.15	1.17	3.26	1.16	3.23

t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001

Table 8. Assessment of the effect of the two major earthquakes on the sale prices of the **Christchurch** area (TC2 & TC3)

	Area designation: TC2				Area designation: TC3			
	(1) Before 9/4/10 quake	(2) After 9/4/10 quake	(3) Before 2/22/11 quake	(4) After 2/22/11 quake	(5) Before 9/4/10 quake	(6) After 9/4/10 quake	(7) Before 2/22/11 quake	(8) After 2/22/11 quake
Const.Year	0.00578***	0.00593***	0.00556***	0.00616***	0.00432***	0.00707***	0.00472***	0.00738***
	(16.39)	(19.21)	(18.15)	(17.95)	(5.11)	(8.06)	(6.34)	(6.72)
Bedrooms	0.123***	0.130***	0.126***	0.127***	0.173***	0.178***	0.157***	0.217***
	(11.56)	(12.93)	(13.51)	(11.38)	(6.62)	(6.20)	(6.95)	(6.09)
Agr.Year	-0.0142	0.0467***	-0.0133	0.0399**	-0.00293	-0.0231	0.00423	-0.108*
	(-1.11)	(5.53)	(-1.36)	(3.07)	(-0.10)	(-0.97)	(0.18)	(-2.43)
Sell_days	-0.000234	-0.000290	-0.000257*	-0.000259	-0.000265	0.000308	0.0000825	0.0000389
	(-1.72)	(-1.57)	(-2.17)	(-1.24)	(-0.65)	(0.70)	(0.19)	(0.08)
Land_area	0.000466***	0.000334***	0.000476***	0.000303***	0.000644***	0.000726***	0.000685***	0.000632***
	(11.16)	(5.16)	(14.10)	(4.45)	(6.87)	(8.25)	(8.72)	(4.19)
Exterior Façade Material								
Brick	0.115	0.0867	0.124*	0.0584	0.0939	-0.436*	-0.00700	-0.477
	(1.90)	(1.35)	(2.49)	(0.75)	(0.98)	(-2.53)	(-0.07)	(-1.94)
Concrete	0.00479	0.00267	0.0181	-0.0240	-0.0134	-0.477**	-0.108	-0.487*
	(0.08)	(0.04)	(0.36)	(-0.31)	(-0.14)	(-2.80)	(-1.09)	(-1.98)
Fibrolite	-0.0540	-0.00463	-0.0586	0.0100	-0.118	-0.475*	-0.208	-0.473
	(-0.76)	(-0.06)	(-0.98)	(0.12)	(-1.13)	(-2.58)	(-1.88)	(-1.86)
Mixture	0.174*	0.214**	0.181**	0.203*	0.322**	-0.142	0.279*	-0.245
	(2.57)	(3.17)	(3.27)	(2.47)	(2.70)	(-0.74)	(2.27)	(-0.92)
Roughcast	0.193**	0.228***	0.184***	0.228**	0.218*	-0.0536	0.153	-0.0724
	(3.08)	(3.54)	(3.56)	(2.92)	(2.11)	(-0.31)	(1.44)	(-0.29)
Stone	0.0643	0.141	0.0659	0.137	0.331	-0.0611	0.212	0.209
	(0.70)	(1.56)	(0.86)	(1.28)	(1.64)	(-0.26)	(1.38)	(0.62)
Wood	0.225***	0.210**	0.226***	0.194*	0.237*	-0.0354	0.165	-0.0158
	(3.59)	(3.28)	(4.38)	(2.46)	(2.40)	(-0.21)	(1.61)	(-0.06)
Roof Façade Material								
Fibrolite	-0.156*	-0.0965	-0.117	-0.119	-0.0532	-0.594***	-0.0956	-0.578***
	(-2.23)	(-1.32)	(-1.58)	(-1.65)	(-0.50)	(-5.15)	(-0.92)	(-5.14)
Malthoid	0.0869	0.365*	0.00672	0.528***	0.246***	0.00867	-0.0194	-0.00400
	(0.76)	(2.27)	(0.06)	(4.09)	(3.39)	(0.04)	(-0.12)	(-0.02)
Mixture	-0.0356	-0.0475	-0.0414	-0.0550	0.258	-0.261	0.00420	-0.400***
	(-0.39)	(-0.43)	(-0.45)	(-0.51)	(0.83)	(-1.92)	(0.02)	(-6.07)
Tile	-0.0647***	-0.0547***	-0.0659***	-0.0511***	-0.0568	-0.0244	-0.0503	-0.0337
	(-4.99)	(-4.95)	(-5.92)	(-4.05)	(-1.95)	(-0.67)	(-1.95)	(-0.72)
_cons	29.24	-93.53***	27.81	-80.18**	9.094	44.58	-5.967	214.9*
	(1.14)	(-5.49)	(1.42)	(-3.06)	(0.16)	(0.93)	(-0.13)	(2.40)
N	1811	2631	2366	2076	616	478	764	330
R-sq	0.452	0.454	0.450	0.461	0.426	0.491	0.455	0.475
vif	4.39	4.38	4.11	4.76	5.25	5.00	5.11	5.17

t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001

Table 9. Assessment of the effect of the two major earthquakes on the sale prices of the **Selwyn** area

	Overall data				Area designation: TC1[+]			
	(1) Before 9/4/10 quake	(2) After 9/4/10 quake	(3) Before 2/22/11 quake	(4) After 2/22/11 quake	(5) Before 9/4/10 quake	(6) After 9/4/10 quake	(7) Before 2/22/11 quake	(8) After 2/22/11 quake
Const.Year	0.00665***	0.00393**	0.00592***	0.00374**	0.00795***	0.00727***	0.00753***	0.00710***
	(4.70)	(3.18)	(4.83)	(2.92)	(5.99)	(5.73)	(5.03)	(5.58)
Bedrooms	0.0874***	0.0426**	0.0828***	0.0360*	0.0510*	0.0272	0.0507*	0.0146
	(4.17)	(2.79)	(4.38)	(2.32)	(2.06)	(1.68)	(2.41)	(1.00)
Agr.Year	-0.0600**	0.0773***	-0.0198	0.0497**	-0.0951*	0.0752***	-0.0191	0.0549
	(-2.67)	(7.19)	(-1.04)	(2.76)	(-2.58)	(4.02)	(-0.59)	(1.87)
Sell_days	-0.0000496	0.000300*	-0.0000505	0.000404*	0.0000175	0.000160	0.0000150	0.0000802
	(-0.43)	(2.19)	(-0.54)	(2.42)	(0.18)	(0.97)	(0.10)	(0.49)
Land_area	0.0000810***	0.000106***	0.0000761***	0.000121***	0.000187***	0.000273***	0.000195***	0.000300***
	(3.36)	(5.63)	(3.64)	(8.20)	(6.19)	(5.52)	(7.62)	(4.90)
Exterior Façade Material[++]								
Brick	-0.169***	-0.0350	-0.131*	-0.0396	-0.0315	-0.000194	-0.0289	0.0204
	(-3.62)	(-0.75)	(-2.39)	(-0.82)	(-0.60)	(-0.00)	(-0.70)	(0.29)
Concrete	-0.119*	-0.0917	-0.121*	-0.0917	-0.0493	-0.0525	-0.0791	-0.0458
	(-2.10)	(-1.55)	(-2.11)	(-1.53)	(-0.92)	(-0.85)	(-1.62)	(-0.65)
Roughcast	-0.133*	0.0565	-0.0688	0.0373	0.0230	0.0984	0.0602	0.0884
	(-2.36)	(0.99)	(-1.10)	(0.67)	(0.27)	(1.23)	(0.78)	(1.00)
Roof Façade Material[++]								
Iron	0.104	0.0501	0.0637	0.0696	-0.0480	0.00225	-0.0755	-0.00801
	(1.97)	(0.67)	(1.05)	(0.90)	(-0.49)	(0.04)	(-0.68)	(-0.13)
Tile	0.0599	0.0388	0.0279	0.0668	-0.115	-0.0000341	-0.0985	-0.0154
	(1.04)	(0.51)	(0.44)	(0.84)	(-1.14)	(-0.00)	(-0.87)	(-0.21)
_cons	119.8**	-150.5***	40.65	-94.67**	188.1*	-153.0***	36.08	-111.9
	(2.66)	(-6.87)	(1.06)	(-2.59)	(2.54)	(-4.04)	(0.56)	(-1.88)
N	219	440	300	359	51	109	69	91
R-sq	0.515	0.483	0.462	0.497	0.786	0.761	0.741	0.764
vif	3.54	3.85	3.88	3.46	2.75	2.96	3.03	2.76

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
[+]: Only TC1 area has sufficiently large number of buildings for more in depth analysis
[++]: Only the façade variables with a significant number of observations are included

Table 10. Assessment of the effect of the two major earthquakes on the sale prices of the **Waimakariri** area

	Overall data				Area designation: TC2[+]			
	(1) Before 9/4/10 quake	(2) After 9/4/10 quake	(3) Before 2/22/11 quake	(4) After 2/22/11 quake	(5) Before 9/4/10 quake	(6) After 9/4/10 quake	(7) Before 2/22/11 quake	(8) After 2/22/11 quake
Const.Year	0.00580***	0.00428***	0.00509***	0.00441***	0.00468*	0.00432***	0.00380**	0.00429***
	(7.27)	(9.80)	(7.74)	(9.09)	(2.63)	(4.72)	(2.87)	(4.02)
Bedrooms	0.0838***	0.120***	0.0940***	0.119***	0.142**	0.159***	0.155***	0.158***
	(4.52)	(9.91)	(5.97)	(8.87)	(2.99)	(8.32)	(3.76)	(6.78)
Agr.Year	-0.00650	0.0721***	-0.000228	0.0692***	-0.0128	0.0806***	-0.00407	0.0630**
	(-0.37)	(6.90)	(-0.02)	(4.83)	(-0.38)	(5.16)	(-0.17)	(2.67)
Sell_days	0.0000809	-0.0000366	0.000165	-0.000128	-0.000404	-0.000493*	-0.000276	-0.000618*
	(0.48)	(-0.28)	(1.09)	(-0.84)	(-1.04)	(-2.24)	(-0.79)	(-2.47)
Land_area	0.000169***	0.0000626**	0.000159***	0.0000614**	0.000148	0.000211***	0.000178*	0.000187***
	(3.83)	(3.17)	(4.15)	(3.23)	(1.65)	(4.74)	(2.14)	(4.17)
Exterior Façade Material								
Brick	0.118*	0.0333	0.108*	0.0128	0.303**	0.0634	0.280**	0.0624
	(2.40)	(0.74)	(2.33)	(0.26)	(3.40)	(1.26)	(3.38)	(1.21)
Concrete	0.0328	-0.0728	0.0212	-0.0905	0.174	-0.0660	0.120	-0.0560
	(0.63)	(-1.60)	(0.44)	(-1.85)	(1.79)	(-1.23)	(1.41)	(-1.02)
Fibrolite	-0.0294	-0.112*	-0.0628	-0.124*	0.218	-0.108	0.161	-0.0965
	(-0.43)	(-2.12)	(-1.03)	(-2.16)	(1.53)	(-1.48)	(1.28)	(-1.18)
Mixture	0.106	0.0350	0.0693	0.0274	-0.161	-0.0707	-0.115	-0.0521
	(1.32)	(0.64)	(0.95)	(0.48)	(-0.66)	(-1.04)	(-0.65)	(-0.80)
Roughcast	0.134*	0.115*	0.141*	0.0918	0.273*	0.0229	0.270**	-0.000779
	(2.24)	(2.28)	(2.56)	(1.69)	(2.64)	(0.38)	(2.76)	(-0.01)
Wood	0.129	-0.00944	0.107	-0.0408	0.214	-0.0625	0.159	-0.0870
	(1.73)	(-0.19)	(1.66)	(-0.74)	(1.54)	(-0.88)	(1.49)	(-1.20)
Roof Façade Material								
Iron[+++]	0.0252	-0.0336	0.0310	-0.0294				
	(0.42)	(-0.75)	(0.61)	(-0.61)				
Tile	0.00694	-0.0383	0.0203	-0.0358	0.0502	-0.0230	0.0623	-0.0327
	(0.11)	(-0.84)	(0.39)	(-0.72)	(1.09)	(-1.13)	(1.54)	(-1.50)
_cons	13.77	-141.1***	2.536	-135.6***	28.23	-158.5***	12.49	-123.0*
	(0.39)	(-6.70)	(0.10)	(-4.70)	(0.42)	(-4.97)	(0.25)	(-2.54)
N	329	799	444	684	81	184	103	162
R-sq	0.621	0.607	0.592	0.613	0.667	0.772	0.709	0.745
vif	4.67	4.55	4.91	4.60	2.92	2.78	3.27	2.65

t statistics in parentheses; * p<0.05, ** p<0.01, *** p<0.001

[+]: Only TC1 area has sufficiently large number of buildings for more in depth analysis

[++]: Only the façade variables with a significant number of observations are included

[+++]: Iron roof façade was dropped for TC2 due to multicolinearity

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