VALUING THE RISK OF IMPERFECT INFORMATION: CHRISTCHURCH EARTHQUAKE

CALLUM LOGAN, SENIOR LECTURER
RMIT UNIVERSITY, MELBOURNE, AUSTRALIA

ABSTRACT

Purpose
This is a background discussion and literature review paper relating to the application of methods to measure the impact of a significant earthquake event on house prices. The purpose of this review is to select the appropriate methodology to the assessment of impacts on Christchurch housing prices. The results of this will form part of a further research paper.

Approach
Previous literature specific to hedonic modelling of earthquake events and their impact on housing is limited. Therefore, a wider review of natural disaster events and types of methodologies are undertaken in this paper.

Findings
The Christchurch earthquake land zoning process combined with government compensation that followed the 2010 earthquake is unique. The literature review suggests that a hedonic pricing modelling using a Difference-in Difference specification may be the most appropriate model for an event of this nature.

Value of research
It is likely that the outcomes of further research will assist in the identification of risk management strategies for the insurance industry, central and local governments. This type of research also has application for other earthquake prone cities as well as other natural disaster risk zones such as flood zones, hurricane and storm surge risk zones along coastlines.

Keywords: Earthquake, price adjustment, risk, compensation, housing

BACKGROUND

On average, there are around 15,000 earthquakes in New Zealand every year. Most of these are small and not of sufficient size to be felt. However the 7.1 magnitude Canterbury earthquake of 4 September 2010 occurred 40km from the city of Christchurch, a metropolitan area containing a local resident population of 348,435 people. Major aftershock events greater than magnitude 6.0 followed, the most devastating of which occurred on 22 February 2011 and left behind collapsed buildings, 182 fatalities and significant property and infrastructure damage. To date, repair and replacement estimates total $20 billion NZD.

In terms of property damage, it is largely regarded that the 22 February event was the most significant.

The shaking intensity and ground speed on 22 February 2011 were at the extreme end of the Modified Mercali scale, a scale used by seismologists to inform planning and building standards. In addition, Christchurch suffered from severe ground liquefaction and lateral spreading which provided a further catalyst for property and infrastructure damage. This risk attribute was well documented prior to the earthquake to the extent that pre purchase Land Information Memorandums (LIM’s) included references to it. If a purchaser’s LIM report made reference to potential liquefaction risk they would then need to make further inquiries with the Regional Council, Environment Canterbury (ECan), to gather more information about the degree of liquefaction and land damage risk specific to the property they wished to purchase.

The geology of Christchurch was identified early on in the city’s history and is well depicted in the ‘Black Map’ of 1856. This ‘Black Map’ shows many swampy land areas across it. Indeed, it may be the first attempt at identifying land quality hazards for the purposes of planning the city of Christchurch. Today, most of these areas are now occupied by residential and commercial land uses, the swamps having been drained and the tributaries filled in long ago.

1 2006 Census of Population and Dwellings
2 Pre-election Economic and Financial Update, NZ Treasury, 25 October 2011
Shortly after the first earthquake all sale and purchase contracts allowed for the transfer of insurance claims for repair and reinstatement as well as the insurance policies themselves. Therefore, no theoretical price discounting should apply since new owners would have their houses repaired or replaced, but the uncertainties surrounding land with new risk categories attached may have resulted in price adjustments. However, there could also be frictional barriers to selling in heavily damaged suburbs where a significant number of homes are physically uninhabitable and unable to be repaired quickly. In this case, a restricted level of habitable supply may have caused upward pressure on prices in those areas if local demand levels remained sufficient. This phenomenon may be a temporary one however, and when homes are repaired, and insurance issues resolved over time there may be a market wide correction of prices as frictional barriers to selling are gradually removed. This phenomenon should be able to be measured and accounted for by testing the significance of a percentage of damage by suburb variable in the model.

It should be pointed out that the land zoning and testing that has occurred post earthquake is far more extensive than the pre earthquake land testing and resultant mapping. Properties near the Avon River which travels through the city and eastern suburbs have experienced significant lateral spreading. In some areas the land has dropped up to 1.5 metres along its banks. At the same time, the river bed has risen creating new flood risks during spring tides for areas such as Bexley. So severe was the damage to land and housing that the New Zealand Government offered to acquire around 5000 houses in Christchurch and Kaiapoi that are sited in what has been categorised as the red zone; a zone deemed uneconomic to repair houses and infrastructure. More recently another red zone has been announced for Port Hills for rock fall risk rather than liquefaction risk. Another 158 houses have been red zoned due to this risk.

The pre earthquake maps were, no doubt, constructed with the best information available at the time from a combination of historical records and core sampling. The reality is an actual event is the best platform from which to develop the best set of earthquake risk land maps. ECan provide spatial distribution maps of pre earthquake liquefaction ground damage potential. There are three other similar versions of this map. The first of these maps illustrates the liquefaction potential only, but there are two versions of the map representing low water table and high water table scenarios. Similarly, there is also a liquefaction and land damage potential map with both low and high water table scenarios. Liquefaction and land damage under a high water table scenario is assumed to represent the worst case. This is the starting point for pre earthquake land zoning to be used to overlay property sales occurring prior to the new land zone announcements.

Figure 1 shows the new map with associated land risk categories. Also shown overlaid on figure 1 are the sales locations of residential properties spanning the period 1 February 2007 to 31 October 2012. There are over 70,000 sales recorded over this period including repeat sales, and each of these sales need to be tagged to its relevant zone according to the date the sale occurred. This study will examine multiple zone change scenarios from pre and post land zone maps. Each of these zone changes can be ranked on a linear scale for use in the DID equation. However, a linear scale may dilute the actual price adjustment as a zone change steps closer to the new worst case zone, TC3. It may be closer to an exponential relationship and an estimation of the model for each specific zone change market may be necessary to achieve more accuracy.

Figure 1: Technical land classes and residential sales
This study will ignore the red zone in figure 1 since Government buy-outs of housing in this zone invalidates any economic model application. Identifying where sales have occurred in relation to the zone changes and when they have occurred is fundamental to this research. Sales of properties where the categorisation of a zone has changed will inform the input for the treatment and control variables for the DID equation. The public notice date for the new zone changes will be represented by a dummy variable in the treatment variable (0 before zone change, 1 after). Because there will be multiple zone changes they need to be ranked based on their degree of step change and the degree of risk now implied by the new zone. Ignoring the new red zone, a simple analysis shows there may be 11 zone change outcomes. Table 1.0 below shows the 11 outcomes of zone change that could occur.

Table 1: Land zone change scenarios

<table>
<thead>
<tr>
<th>Step change</th>
<th>Scenarios possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No risk to TC3</td>
</tr>
<tr>
<td>2</td>
<td>Low risk to TC2</td>
</tr>
<tr>
<td>3</td>
<td>No risk to TC3</td>
</tr>
</tbody>
</table>

*The variables in red represent the rankings applied from the worst outcome (1), to the best outcome, (11). As the cost implications for rebuilding a TC3 home are the highest followed by TC2 and TC1 then the assumption is that a step change of one step from TC2 to TC3 is worse than from TC1 to TC2. Similarly, a one step change from TC3 to TC2 is considered better than a one step change from TC2 to TC1.

PREVIOUS LITERATURE AND DISCUSSION

Specific property research on hedonic price adjustment following earthquakes is limited. There are a number of appraisal/valuation papers examining disaster effects on value but, these tend to have limited sample size. Murdoch et al. (1993) specify a hedonic model for the estimation of house prices following the Loma Prieta earthquake. Their specification includes a dummy variable representing the earthquake event itself plus property specific and neighbourhood specific attributes. They find a significant relationship between the earthquake event and a decline in prices. Unlike the experience of the Loma Prieta housing market, house prices in Christchurch have been found to increase following the earthquake. This is suspected to be a function of the degree of damage to houses causing a frictional effect and disrupting a normal supply of property listings which, in turn, is creating price appreciation in the Christchurch market. Furthermore, the red zoning and government compensation paid to approximately 5000 households has created a demand spike for alternative housing. Compounding the problem further were insurance limitations for new home building and high construction risk excess costs.

Figure 2 shows the Christchurch residential price index relative to 2007 peak prices. The two blue dots on the index represent 12 months price appreciation of 5.5%. Neighbouring territorial authorities of Selwyn and Waimakariri recorded 14.4% and 13.4% over the same period. With the exception of the town of Kaiapoi within the Waimakariri district, both jurisdictions have less liquefaction and land damage risk, and the relative index appreciation is likely to reflect the substitution effect of people relocating to better land zones over this period. Overlaid on figure 2 are the key event dates. As can be seen house prices have trended upwards since September 2010. The exceptions to this general trend are the two short periods immediately after the two major earthquake events. However once the red zone announcements were made they have appeared to have provided a catalyst for general price appreciation.

Anderson et al. (1986) examine mortgage default risk following the 1971 San Fernando earthquake. They find that the decline of net equity following the earthquake to be the most significant factor impacting mortgage default. Other significant variables included personal and financial issues, and property value. It should be pointed out that unlike Christchurch there were very few households that had insurance cover for earthquake damage in San Fernando in 1971. This was due to high premium and excess costs and the extended period of time between earthquakes. All the properties included in the study had no earthquake cover. This is in stark contrast with Christchurch where the majority of homeowners insurance includes earthquake cover.

Brookshire et al. (1986) examine the expected utility hypotheses that when provided adequate information, consumer behaviour will result in a price gradient for housing that accounts for earthquake risk. They also assess the impact of the introduction of a 1974 state law which provided for disclosure of earthquake risk information. They found that the new Act effectively created a market for ‘safe’ housing that, prior to the Act, did not exist. Both the Los Angeles and San Francisco areas are examined. The study assessed consumer behaviour in a low-probability, but high damage natural event context. Despite the low-probability element, their study showed a rational consumer response to information about risk resulting in a price gradient reflecting a premium for safety.
Prior to 4 September Christchurch earthquake, the city’s experience with earthquakes was limited to two events around magnitude 5-5.5 in 1869 and 1870 and one stronger 7-7.3 magnitude event in North Canterbury in 1888 which toppled the spire of the city’s Cathedral. There have however been plenty of other earthquake events in Arthur’s Pass, Lake Coleridge and Hanmer Springs which are closer to the Southern Alps and at least 100km from Christchurch. The return period for the blind fault that caused the February 2011 rupture has been estimated to be in the order of 10,000 years\(^3\). The degree of attention paid by consumers to the pre earthquake land risk maps will be worth examining to see if the same logical price gradient reflected the level of risk.

PROPOSED METHODOLOGY AND DISCUSSION

Efficient pricing theory suggests that consumers will account for all available information in their pricing decision for goods. This applies to the purchasing of housing, which is often a household’s biggest investment. Where imperfect information exists, then by definition, there is a risk of mispricing.

Equilibrium in the housing market is represented by price distributions that can be measured by a hedonic model. The foundations of this type of model were originally specified by Rosen (1974). Rosen specifies a hedonic model whereby goods are valued by reference to their utility bearing attributes. It is based on the premise that maximum household utility is derived subject to household budget constraints. He defines hedonic pricing as the implicit pricing of attributes revealed to the market from actual prices for different products and their specific attributes or characteristics. Each price point represents the maximisation of someone’s utility function subject to budget constraints. In a normal market

\[^3\] Canterbury Earthquake Royal Commission. Royal Commission of Inquiry Interim Report Section 3: Inquiry Issues and Recommendations
where no exogenous shock had occurred, the model would simply include property and location attributes to estimate the different price points. In this case however, we have to account for the exogenous shock. This is accounted for by introducing earthquake risk attributes.

A proposed hedonic Difference-in-Difference (DID) specification for this research will examine the impact of land zone categorisation changes on residential prices. This type of specification is common for event studies such as zone changes. This type of specification has a potential for inconsistency in the standard errors. Tests of the model will be conducted to examine whether this issue is present and the appropriate solution applied. The solution may take the form of data transformation, dropping the constant term, different estimation method other than OLS, or a different mathematical model.

DATA REQUIREMENTS
This research will utilise Geospatial software to overlay land zones shape files on property sale locations as well as assist in the development of a neighbourhood attribute and earthquake attribute database.

SALES DATA
The sales data set is pooled. The benefit of this over using a sales index is that it provides much more variation and greater degrees of freedom. The data have been sourced from Headway Systems Limited who hold all sales data for New Zealand sales transactions. The data span the period 1 February 2007 to 31 October 2012 and they will be appropriately deflated using the New Zealand Consumer Price Index (CPI). Only residential dwelling data is used, and rural sales, lifestyle block sales and commercial sales are excluded.

In addition to sales prices, the data also includes the following independent variable data sets:

Table 2: Variable data list

<table>
<thead>
<tr>
<th>Variable category</th>
<th>Variable</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Attribute Data</td>
<td>Dwelling floor area</td>
<td>Square metres</td>
</tr>
<tr>
<td></td>
<td>Lot Size</td>
<td>Square metres</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>Age in years to nearest decade</td>
</tr>
<tr>
<td>Neighbourhood Attribute Data</td>
<td>School quality</td>
<td>2010 NCEA Level 3 score in relevant school zone</td>
</tr>
<tr>
<td></td>
<td>Distance to public transport</td>
<td>Kilometres</td>
</tr>
<tr>
<td></td>
<td>Ocean boundary/view</td>
<td>Kilometres</td>
</tr>
<tr>
<td></td>
<td>Population</td>
<td>Density per Area Unit</td>
</tr>
<tr>
<td></td>
<td>Crime</td>
<td>Reported crimes per household in each Area Unit</td>
</tr>
<tr>
<td>Earthquake Attribute Data</td>
<td>Event(s) themselves</td>
<td>Dummy variable represented by 0 before and 1 after the earthquakes</td>
</tr>
<tr>
<td></td>
<td>House damage</td>
<td>Percentage of homes damaged by suburb</td>
</tr>
<tr>
<td></td>
<td>Liquefaction risk zone changes pre and post event</td>
<td>A dummy variable is used in the treatment variable for each of the zone changes represented 0 before and 1 after the new land zone announcement</td>
</tr>
<tr>
<td></td>
<td>Proximity to new fault lines</td>
<td>Kilometres plus dummy variable, 0 before and 1 after new fault line</td>
</tr>
</tbody>
</table>
CONCLUSION

GIS will enable the spatial distribution of land zone category changes and their associated price impacts on housing to be examined. Unlike other earthquake studies on house prices, this study will be unique due to the complex land zoning and Government compensation processes. It is likely that the outcomes of this study will assist in the identification of risk management strategies for the insurance industry, central and local governments. This type of research also has application for other earthquake prone cities as well as other natural disaster risk zones such as flood zones, hurricane and storm surge risk zones along coastlines. When disasters occur, disequilibrium in the local property market occurs followed by a period of adjustment. Valuers, lenders and insurers will also understand more about these adjustments through this research. In addition, central and local Government can account for more accurate cost-benefit inputs in their assessment of risk which will assist in informing policy, and enable the matching of appropriate building and infrastructure standards to land zoning, or indeed inform whether certain land types are beyond any risk mitigation standards such as Christchurch’s red zone.

This research study will commence in 2013.

Email contact: callum.logan@rmit.edu.au
REFERENCES


