Earthquakes and Auctions: The Christchurch Housing Market 2010-2012

Michael LaCour-Little, Ph.D.
Professor of Finance
California State University - Fullerton*
5133 Mihaylo Hall
Fullerton, CA 92834-6848
mlacour-little@fullerton.edu

Early Draft for the Asian Real Estate Society Meetings

Not for Citation

March 30, 2014

Abstract

This paper uses hedonic regression to examine prices in the Christchurch housing market before and after the recent severe earthquakes. Christchurch housing prices were relative stable prior to the earthquakes but increased rapidly thereafter, consistent with the contraction of supply and increased demand from displaced households and a net influx of workers involved in the rebuilding effort. In addition, I find that the use of auctions increased after the earthquakes and that auctioned properties command significantly higher prices as compared to other sales methods, helping to explain the increased interest in this form of price discovery. Results are robust after correcting for potential sample selection bias.

Key words: housing prices, earthquakes, auctions, hedonic regression

*Research initiated in 2013 while an Erskine Fellow at the University of Canterbury, Christchurch, New Zealand.

Introduction

Christchurch, New Zealand's second largest city, was rocked by major earthquakes during 2010 and 2011, resulting in significant loss of both residential and commercial buildings. By some estimates, approximately 70% of the downtown central business district (CBD) was, or will have to be, demolished. Tragically, there were 185 fatalities during the 2011 quake which occurred mid-day during the work week. Moreover, approximately 8,000 residences in the city and nearby suburbs were rendered uninhabitable. In this paper, I examine the effect of these devastating natural disasters on the local housing market. In the process, I extend and update earlier work on residential property auctions in New Zealand by Dotzour, Moorhead, and Winkler (1999). Briefly, I find that house prices were relatively stable prior to the earthquakes, increased sharply following the earthquakes, and that the use of auctions to sell properties increased significantly, too.

Studying the Christchurch housing market under such conditions can lead to a number of insights. First, we can see how prices respond to an entirely exogenous shock. Second, we can see how sellers and agents adapt their marketing approach to newly changed circumstances. Third, we can assess whether there are changes among the factors, or the weighting of the factors, that affect house values. Finally, we can gauge whether the findings of Dotzour, Moorhead, and Winkler (1998) persist.

The plan for the balance of the paper is as follows. In the next section, I provide more detail on the earthquakes and their effect on the city and its environs. In the third section, I provide an overview of the New Zealand housing market with a focus on Christchurch. The fourth section reviews the relevant literature both on the effect of natural disasters on housing prices and on the use of auctions to sell residential properties. In the fifth section, I describe the data used for the analysis presented. In sixth section, I sketch out the modeling method, present and discuss empirical results. The final section offers conclusions and extensions.

Christchurch and the Christchurch Earthquakes

Christchurch is New Zealand's second most populous city with a population of almost 400,000 in the city and immediate suburbs[1]. Unlike Auckland and Wellington, the country's two other major population centers both of which are located on North Island, Christchurch is located inland on the South Island's Canterbury Plain, a large, relatively flat area on the eastern side of the Southern Alps. The latter extend as a ridge down through the South Island, dividing the country's less developed West Coast from the more developed East Coast communities. The Canterbury region is a highly productive agricultural region with goods shipped in and out through Lyttleton Harbor, located about seven miles southeast of Christchurch. Christchurch functions as the primary commercial center for the entire South Island, which is generally less populated than the North Island. Christchurch is located about seven miles inland from the Pacific Ocean with many of its eastern suburbs build on relative marshy land with a high water table, a geological fact that contributed to the concentration of the worst earthquake damage in those areas.

[1] Statistics New Zealand (2012). Before the earthquakes, Christchurch had overtaken Wellington to become the country's second largest city. http://www.stats.govt.nz/browse_for_stats/population/mythbusters/Chch-overtakes-wellington-population.aspx [accessed March 30, 2014].

New Zealand has long been plagued by earthquakes and a particularly strong one measuring 7.1 on the Richter scale struck on September 4, 2010 ("the first quake"). The epicenter, however, was in a relatively rural area outside of Christchurch and that fact, together with its depth and time of day (4:30 a.m.) limited casualties and damage. Technically an aftershock of the larger quake, the second major earthquake, measuring 6.3 on the Richter scale, struck on February 22, 2011 ("the second quake"). Due its epicenter center only slightly southeast of the CBD, its relatively shallow depth, and its timing (12:51 p.m. on a work day), the second quake produced damage labeled "destructive" by the Canterbury Earthquake Authority ("CEA"), the government agency charged with managing recovery and rebuilding efforts in the region[2]. The second quake was also rated VIII on the Mercalli scale[3] and its most dramatic effects occurred in older unreinforced masonry buildings in the CBD. In addition, the second quake caused liquefaction in many of the eastern suburbs causing entire neighborhoods to be rendered uninhabitable. A number of smaller after-shocks followed.

The New Zealand and Christchurch Housing Markets

The homeownership rate in New Zealand is approximately 65%, comparable to that of the United States. Nationally, the median house price was $390,000 NZ$[4] as of April 2013, with higher prices in the major cities of Auckland, Wellington, and Christchurch (Real Estate Institute

[2] See http://cera.govt.nz/recovery-strategy/overview/read-the-recovery-strategy for further information.

[3] A rating of VIII on the Mercalli scale is characterized by "damage slight in structures of good design, considerable in normal buildings with a possible partial collapse. Damage great in poorly built structures. Brick buildings easily receive moderate to extremely heavy damage. Possible fall of chimneys, factory stacks, columns, monuments, walls, etc. Heavy furniture moved" Source: U.S. Geological Survey www.earthquake.usgs.gov.

[4] The New Zealand dollar (NZ$) has traded at roughly US$0.80 - $0.85 recently.

of New Zealand, 2013). Rental properties (flats) have prices quoted on a weekly basis which, for convenience and comparability to U.S. numbers, I have converted to monthly equivalents. As of April 2013, the median rent was NZ$1,473 per month. As might expected, larger cities have higher median rents, including Auckland (NZ$1,820), Wellington (NZ$1,733), and Christchurch (NZ$ 1,538). As the data used in this study is limited to housing prices for properties selling during 2010-2012, the effect of the earthquakes on the Christchurch housing market is out of the scope of this paper. Massey University (2013) reports, however, that "As expected Christchurch led the annual rent increase (10.9%)" for the period February 2012 to February 2013, corresponding the one-year growth rate after the second quake.

Literature Review

Natural disasters, whether floods, hurricanes, tornados, or earthquakes provide an exogenous shock to the stock of housing in affected areas and prices generally rise sharply afterwards. Moreover, properties located in hazard-prone areas appear to sell at a discount to otherwise similar properties in less risky locations and the discount associated with a particular risk often is found to increase following an event, as market participants are reminded of the natural hazards they face. A few examples from the literature are illustrative.

Vigdor (2008) reports that the median price of an owner-occupied house in Orleans Parish increased by 59% as a result to the destruction caused by Hurricane Katrina. Moreover, median rent rose from $566 to $838, a 48 percent increase in the same two-year time period. Bin and Polasky (2004) examine data from an area of North Carolina affected by

Hurricane Floyd. Using hedonic regression, they find that houses located within a floodplain have lower market values than similar houses located outside the floodplain and that the magnitude of floodplain discount increased significantly after Hurricane Floyd. Speyrer and Ragas (1991) also examine the effect on house prices of floodplain location, confirming earlier results that such properties sell at lower prices, using data from the New Orleans area. Michio, Seko, and Sumita (2009) use nationwide data from Japan to analyze earthquake risk, its effect on house prices, and the magnitude of the earthquake risk discount before, and after, large earthquakes. They find a price discount associated with particularly earthquake prone areas and that the price discount from locating within a quake-prone area is significantly larger soon after earthquake events than previously.

The research on the effect of hazard related price discounts is not entirely consistent, however. For example, Beron, Murdoch, Thayer, and Vijverberg (1997) use data from California to examine the pricing of earthquake risk before and after the Loma Prieta earthquake[5]. They find that households over-estimated the risk of earthquake-related property damage prior to the earthquake and that the price discount associated with such risks actually decreased following an event. One might characterize such effects as reflecting adaptive learning.

Turning to methods of sale, a large literature has focused on auctions and bidding strategies, including sealed bid, open outcry, and Dutch auctions. Reviews may be found in McAfee and McMillan (1987) and Milgrom (1989). Since our focus is on the empirical side, we will not review these studies here. As a broad characterization auctions, rather than negotiated sales, tend to be used to sell distressed properties in the U.S. whereas a number of

[5] The Loma Prieta earthquake, measuring 6.9 on the Richter scale, struck the San Francisco Bay Area in October 1989 causing a collapse of a portion of the San Francisco-Oakland Bay Bridge.

other countries use auctions more broadly, notably Australia and New Zealand. Exactly why these practices differ is unclear.

A number of empirical studies examine house prices when sold by auction often using data from countries outside the U.S. Corder (2010) argues that properties sold in the auction market will tend to have lower reservation prices than properties sold otherwise, increasing the probability of a sale and reducing the effect of any inertia inhibiting the reduction of prices in a declining market. Using data from the U.K., Corder finds that auction use spiked during the 2008-2009 market downturn and price movements appear to lead other indices by about one quarter. In a study using methods similar to those employed here, Frino, Lepone, Mollica, and Vassallo (2010) examine the price effect of the auction sales method in five major Australian cities. Using hedonic regression, they find a price premium associated with auction sale across cities. Moreover, this price premium persists after controlling for sample selection bias associated with those properties selected for auction sale.

Ong, Lusht and Mak (2005) examine the use of auctions using data from Singapore. They find that bidder turnout and market conditions, as well as the choice of auctioning agent, are all important factors in explaining successful auction sales, defined as sales that exceed the seller's reservation price.

Mayer (1998) examines the use of auctions to sell real estate in the U.S., noting at the outset that auctions are typically used to liquidate distressed properties, rather than for "normal" transactions. Using data from Los Angeles during the 1990s market downturn and from Dallas during the 1980s market downturn, he estimates repeat sales indices that houses sold at auction sold at discounts ranging from 0-20% compared to non-auction sales.

Other work related specifically to earthquakes in Wellington, New Zealand, include Clarke (1998) and Prentice (2005). Issues related to the highest and best use analysis performed by appraisers following a natural disaster is discussed in Epley (2010).

The paper most directly related to this work is Dotzour, Moorhead, and Winkler (1998). Like the present study, Dotzour et al use data from the Christchurch, though the data employed was from the early 1990s, many years prior to the recent earthquakes, of course. They also use hedonic regression and report that auction sales produce a price premium after controlling for other factors[6], with that premium larger in high prestige neighborhoods than in elsewhere. I build on this important early study in the work here, extending it by examination of the effect of the Christchurch earthquakes and by assessing the effect of revealed asking price among those properties that were not sold by auction. I hypothesize that auction usage will increase following the earthquakes as the market is rising rapidly, due to reduced supply, and it becomes difficult for agents and appraiser to gauge prices due to greater uncertainty in the market.

Data

Data on house sales during 2010-2012 was acquired from the commercial firm, PropertyIQ. The data vendor merges public record data on property sales and other property characteristics maintained by taxing authorities with realtor data to identify mode of sale. Sales between related parties and sales to the crown, i.e., the government, are excluded. While data is reasonably comprehensive, including property age, size of building and lot, number of

[6] Due to data sources, their hedonic specification is slightly different from the one employed here.

bedrooms, total square footage, and building condition (rated good, average, or poor), several variables often used in hedonic regression and related analyses were not available. These included number of bathrooms and listing details sufficient to determine time on market. On the other hand, we do have detailed locational information for each property, including the neighborhood or suburb in which it is located, a ranking of neighborhood quality on a five point scale[7], and a three point scale rating by the Canterbury Earthquake Authority that specifies foundation techniques that must be used in any re-building given soils conditions.

Methods of sale include multiple categories, including negotiations based on an asking price, negotiations based on a stated minimum price, negotiations based on an invitation to offer without any stated asking price. I group all of these included the negotiation category and will separately consider the issue of asking price later in the analysis. Mortgagee auctions and mortgagee sales are combined into a distressed sale category and not included with the standard auctions analyzed. It is possible, of course, that some standard auctions are actually distress sales by sellers but actual seller motivation is unobserved. If distressed sales tend to occur at discounts any estimates of premiums identified would be biased downward were such sales included.

Descriptive statistics on the entire dataset appears in Table 1A. The mean house size is 1,577 square feet and the mean price sold per square foot is $250. Mean lot size is 0.07 acres. For those properties where an asking price was set (about 70% of all observations), the mean asking price was $211,000. The mean sold price, net of any personal property was $379,000.

[7] This ranking was kindly provided by emeritus faculty Everard Moorhead, one of the authors of the 1998 paper on New Zealand house prices previously cited. In addition to serving as a Lecturer at Lincoln University, he was a professional appraiser in the Christchurch market for many years and these rankings represent his expert judgment.

This large difference reflects the fact that it is the higher-priced properties that tend to be marketed without a firm asking price stated. Properties average 3 bedrooms and are 40 years old at time of sale. About 72% of all properties are categorized as in good condition; another 27% are classified as average condition and only about 1% are categorized as poor condition. Over the entire three-year period studied, 11% of properties are sold at auction and 89% are sold by negotiation. Fewer than 1% are distressed sales, including mortgagee auctions and post-auction (real estate owned or "REO") sales.

I divide the data into three time periods: the pre-quake period (the first eight months of 2010); the quake-period (Sept 4, 2010 to February 21, 2011 and six months thereafter, ending in August 2011); and the post-quake period (thereafter, ending in Dec 2012). The choice of dates and, therefore, time periods is necessarily somewhat subjective but the choices made seemed reasonable and produced adequate size samples of relative sizes 25%, 25%, and 50%[8]. In Table 1B, means of the same variables discussed above are presented by period.

Mean values of most variables are not dramatically different by period. Price per square foot increased from $241 in the pre-quake period to $260 in the post-quake period. The percentage of properties sold via auction increased from 8.5% in the pre-quake period to 12.1% in the post-quake period. There is no noticeable difference in the distribution of quality rankings, suggesting that seriously damaged properties (which presumably would be rated as "poor" in condition) may have been withheld from the market during the quake and post-quake periods. It is also unclear from the data exactly when these quality rankings were assigned. In

[8] We initially started the post-quake period immediately following the second quake, producing approximately equal size samples by period. Overall results are qualitatively similar and accounting for some recovery period following the second quake seemed appropriate.

any event, as sales to the government resulting from settlement of earthquake insurance claims are excluded from the data set, this is a plausible pattern. As of 2013, a number of households with whom the author spoke were still waiting for insurance claims to be settled.

I calculate the percent auction of all transactions with known sales method monthly and graph the results in Figure 1. An upward trend seems evident with some spiking in the middle of the 36 month time period that would correspond to April-June of 2011, a few months following the second quake. Low values (less than 5% of all transactions) occur consistently during January of each year and we speculate that this is simply a seasonal phenomenon due to prior's months Christmas holiday. The upward trend apparent would be even stronger, of course, were these observations excluded as outliers.

Regression Analyses

Overview

I estimate simple hedonic regressions by period, including time (measured by monthly dummy variables[9]) to see how house price appreciation rates changed after the earthquakes occurred. Sales method is then added to the specification to assess its effect on prices during each of the three time periods defined. Neighborhood quality is measured by prestige ratings described in Dotzour et al (1998). As a robustness check, we re-estimate without the neighborhood prestige rankings but simply including dummy variables for the 40 or so city

[9] A variety of measures of time were tested, all producing qualitatively similar results.

neighborhoods and suburbs. This improves model fit as measured by adjusted R-squared and probably reduces the spatial correlation as compared to using the neighborhood rankings.

The Effect of the Earthquakes on Prices

Tables 2A, 2B, and 2C present the simple regression results for the three periods. While results are generally quite stable in terms of the signs and magnitudes of coefficients, some notable differences are apparent. First, the coefficient on time (representing a monthly dummy variable) switches from a small, and modestly significant, negative value in the pre-quake period to large, positive and highly significant values in the two following periods. Second, the coefficient on property age, positive in the first two periods, switches to negative in the post-quake period[10]. Third, the discount for a quality rating of “poor” increases and the premium associated with a quality ranking of “good” increases in the post-quake period, as measured by the size of negative and positive coefficients, respectively. All of these results seem consistent with prices increasing sharply after the quakes and buyers becoming relatively more sensitive to property age and condition following the quakes. I also note the coefficients on land size increases substantially and are statistically significant during the quake and post-quake periods, whereas they are not significant in the pre-quake period. Model fit is reasonable given our limited set of covariates with adjusted R-squared values in the 0.60-.80 range.

[10] Normally, the age variable should be negative in a hedonic regression. Exceptions to this rule occur occasionally, however, when urban areas have older higher quality neighborhoods surrounded by lower-quality (but newer) suburbs. We speculate that the change in sign noted here reflects buyer awareness of the downsides to older construction following the earthquakes.

The Effect of Sales Method on Prices over the Three Periods

Next we expand the simple specification to include mode of sale, including the two auction categories (a standard auction "AUCTION" versus a foreclosure auction "FCLR") with a hold-out category of negotiated sale. Results appear in Tables 3A, 3B, and 3C. All of the results described in the previous paragraph continue to hold with the addition of sales method. Foreclosure is statistically significant in the quake and post-quake periods, but not in the pre-quake period. Coefficients suggest a discount for such distress sales of 18-26%. Though not our focus here, these values are similar to those obtained by other researchers discussed earlier. For non-distress auctions, on the other hand, coefficients are consistently positive and statistically significant, with premiums of 9%, 7%, and 11%, during each of the three periods.

Robustness Test on the Effect of Auctions on Prices

As a final step, we replace the neighborhood ranking variable with 82 dummy variables for the neighborhood/suburb name. In addition, we add the Canterbury Earthquake Authority's designation of soil stability, represented by dummy variables TC2 and TC3, with TC1 (the best category) as the reference group. Results appear in Tables 4A, 4B, and 4C.

In general, all of the results described in the previous paragraph persist when location controls, rather than neighborhood quality rankings, are applied. Age is now negative and statistically significant in the pre-quake period, when it had not been in previous specifications.

This could be because of a correlation between neighborhood prestige ranking and housing stock age. High prestige neighborhoods are generally well-established and have earned their reputation over time, so the housing stock is older. Land area is positive and now weakly significant (t-ratio of 1.5) in the pre-quake period. As with property age, this effect may be related to the correlation between older, well-established neighborhoods and lot size, as newer development employs smaller size lots.

Results for auction premiums and distress discounts continue to be statistically significant though magnitudes are attenuated. Non-distress auctions now appear to produce price premiums of 3.4%, 1.9%, and 7.5% during the pre-quake, quake, and post-quake periods, respectively. The variable on soil quality (TC2 and TC3) performs less consistently, with changes in sign and significance level dependent on time period, although during the post-quake period a property with a TC3 rating (the worst rating), the discount is 6.0%. As it is unclear exactly when these ratings became known to the market, perhaps this weak performance is to be expected.

The Role of Asking Price for Non-auctioned Properties

Let us now turn to the effects of sales methods within the category of negotiated sale, i.e. the subset of transactions where open outcry auctions are not used. Differences exist primarily in how the seller's asking price (or reservation price) is revealed. I begin by examining the incidence and effect of establishing a posted price (asking price).

About half (45%) of all sales over the three periods studied include an asking price and we include this information utilizing an indicator variable (PRICED). In this case, we have only negotiated sales, no auctions, and no foreclosures. I then replicate the regression analysis presented in Table 3 for each of the three time periods, eliminating the foreclosure category and replacing the AUCTION dummy variable with PRICED. Results appear in Table 5. In general, signs and magnitudes of coefficients are very close to those shown in Table 3. For example, in Table 5 the coefficients on time are -0.003, 0.003, and 0.006 for the pre-quake, quake, and post-quake periods, respectively. In Table 3 corresponding values are -0.004, 0.003, and 0.007. Likewise, the coefficient on age is positive in the pre-quake period and significantly negative in the post-quake period.

Our variable of interest, PRICED, is negative and statistically significant during all three time periods, suggesting that revealing an asking price early in the sales process has a negative effect on ultimate price. This rather surprising result is inconsistent with the large literature on asking prices suggesting an endogeneity problem which will have to be dealt with in subsequent revisions to the paper. Reviewers have suggested two-stage least squares and this will likely be the first step.

The Effect of Setting a Minimum Bid

Among properties that include an asking price, there is also a subset (about 10% of all transactions) where that price is presented to the market as a minimum acceptable offer[11].

[11] The exact language is "Offers over $$$ will be considered".

Such a marketing approach could reflect the seller's actual reservation price, their pre-disposition to negotiate price, or something about their level of motivation. Presumably a "highly motivated" seller would not insist on a stated minimum in their marketing material, for example.

Our first analysis is to determine whether sellers held to those stated minimums, i.e. did the ultimate sale price always equal or exceed the stated minimum? Interestingly, a large number of sales (718 out of 1,044 total cases with minimums stated) were concluded at prices *below* the stated minimum. One might characterize these sellers as bluffing. The question remains, however, whether those sales were at prices higher or lower than those of similar properties that simply included an asking price but that did not indicate that offers below that that stated asking price would be rejected. To address this question, we replicate the analysis shown in Table 5 limiting the sample to properties with a stated asking price and controlling for the variable of interest with another dummy variable, STATEDMIN. Results appear in Table 6, again separately estimated by time period.

Again, the overall signs and magnitudes of coefficients are consistent with prior results. For example, property age is not significant pre-quake but negative and statistically significant in the quake and post-quake periods. Likewise, prices were not increasing during the pre-quake period, but are appreciating rapidly in the quake and post-quake period. Our interest, however, is on the variable STATEDMIN, reflecting whether the seller indicated that the stated asking price was a minimum that would be considered. Interestingly, the coefficients on STATEDMIN are positive and statistically significant for each of the three periods. Their magnitude is relatively small, however, and may be interpreted as price premiums in the 1-5% range, smaller than the premiums we found for the auction mode of sale, for example. Apparently, while many sellers bluffed when indicating that they would not consider lower offers, the overall effect of stating a minimum acceptable bid is at least slightly positive. As stated previously, however, all of this analysis is subject to revision based on the endogeneity issues previously noted.

Selection Bias Issues

Our study thus far is subject to possible sample selection bias issues. Not all of our original dataset contained information on the mode of sale. If properties with that variable omitted are systematically different from others, there may be a problem. I address this issue using the well-known Heckman correction method.

Briefly, I estimate a probit model for the probability that mode of sale is not reported. A transformation is then used to create the well-known Mills ratio and include that variable as a control variable in our hedonic pricing models. In the interest of brevity, I do not present the probit model, nor the entire regression output with the Mills ratio included in the specification. Rather, in Table 7, I simply show the coefficient on the variable of interest (AUCTION) before and after the Heckman correction accomplished by including the Mills ratio in the model.

Changes are relatively slight after the Heckman correction. In the specification utilizing neighborhood ranking after the Heckman correction, the coefficient on AUCTION decreases by .002, .005, and .027 in the pre-quake, quake, and post-quake periods, respectively. Yet in all cases, the coefficient is still positive and highly statistically significant. In the second specification that utilizes neighborhood dummy variables rather than neighborhood rankings, the coefficient on AUCTION increases, rather than decreases, in the pre-quake and quake periods. In the post-quake period, however, the coefficient decreases from .075 to .059. Overall, the coefficient on AUCTION sale is positive in all cases with magnitudes ranging from a low of about 2% to a high of about 11%, depending on the specification used.

Conclusions

In this paper I have built on the work of Dotzour, Moorhead, and Winkler (1998) to examine the effect of the recent Christchurch earthquakes on the local for-sale housing market. Housing prices were relatively stable prior to the earthquake but increases rapidly thereafter, consistent with the basic principles of supply and demand. The use of auctions to sell properties increased in the quake and post-quake periods as well, probably because in a rapidly increasing market, seller's believed auctions would reduce the risk of underpricing.

Using hedonic regression I estimate that use of the auction sales method adds between 2-11% to the sales price after controlling for other factors. Results are qualitatively robust to a Heckman correction for sample selection bias occurring because mode of sale is not uniformly reported for all transactions in the data. There is some evidence that it may be the higher quality properties may be those selected for the auction sale method, a result consistent with Dotzour et al (1998).

Considering only the non-auctioned properties, I also found that stating an asking price had a slightly negative effect on final sales price. On the other hand, stating a minimum above which offers would be considered had a slight positive effect on final realized price, controlling for other factors. Since auction sales were the primary focus of this research, these latter two findings, while provocative, have been less thoroughly tested and so remain interesting topics for further extensions in progress. Among these are developing hypotheses for the questions addressed and dealing with potential endogeneity issues.

Acknowledgments

Sandy Bond, Mark Dotzour, Ev Moorhead, and Daniel Winkler provided helpful comments on earlier versions of this manuscript. Remaining errors and omissions are exclusively my own.

References

Ashenfelter, Orley and D. Genesove. 1992. Testing for Price Anomalies in Real Estate Auctions, *American Economic Review*: 501-05.

Beron, K.J., J.C. Murdoch, M.A. Thayer, and W.P.M. Vijverberg (1997). An Analysis of the Housing Market Before and After the 1989 Loma Prieta Earthquake. *Land Economics* 73(1):101–113

Bin, O. and Polasky, S. 2004. Effects of Flood Hazards on Property Values: Evidence Before and after Hurricane Floyd. *Land Economics*, 80, 490-500.

Clark, M. (1998). The Economic Effects of a 1998 Wellington Earthquake (No. 98/17). Wellington: NZ Institute of Economic Research, Inc.

Corder, Matthew. 2010. Residential Property Auction Prices. Bank of England *Quarterly Bulletin* 2010 Q3: 199-204.

Dotzour, Mark, Everard Moorhead, and Daniel T. Winkler. 1998. The Impact of Auctions on Residential Sales Prices in New Zealand. *Journal of Reseal Estate Research* 16(1): 57-72.

Epley, D. (2010). Reconsidering the Definition of Highest and Best Use: The Case for a Post-Disaster Highest and Best Use. *Real Estate Issues* 35(2): 59-71.

Frino, Alex, Andrew Lepone, Vito Mollica, and Anthony Vassallo. 2010. The Impact of Auctions on Residential Sales Prices: Australian Evidence. http://ssrn.com/abstract=1665933 .

Heckman, James J. 1979. Sample Selection Bias as a Specification Error. *Econometrica* 47(1): 153-61.

Lusht, Kenneth. 1996. A Comparison of Prices Brought by English Auctions and Private Negotiations. *Real Estate Economics* 24: 517-30.

Mayer, Christopher.J., 1998. Assessing the Performance of Real Estate Auctions. *Real Estate Economics* 26: 41-66.

Massey University, 2013. NZ Rental Market, Quarterly Survey Volume 16(1). Real Estate Analysis Unit, School of Economics and Finance.

McAfee, P. and J. McMillan. 1987. Auctions with a Stochastic Number of Bidders, *Journal of Economic Theory* 43: 1–19.

Michio, Naoi, Miki Seko, and Kazuto Sumita. 2009. Earthquake Risk and Housing Prices in Japan: Evidence Before and After Massive Earthquakes, *Regional Science and Urban Economics* 39(6) 658-669.

Milgrom, R. P. Auctions and Bidding: A Primer. *Journal of Economic Perspectives* 3: 3-22.

Ong, Seow E., Kenneth Lusht and Chee Y. Mak. 2005. Factors Influencing Auction Outcomes: Bidder Turnout, Auction Houses, and Market Conditions. *Journal of Real Estate Research* 27(2): 177-191.

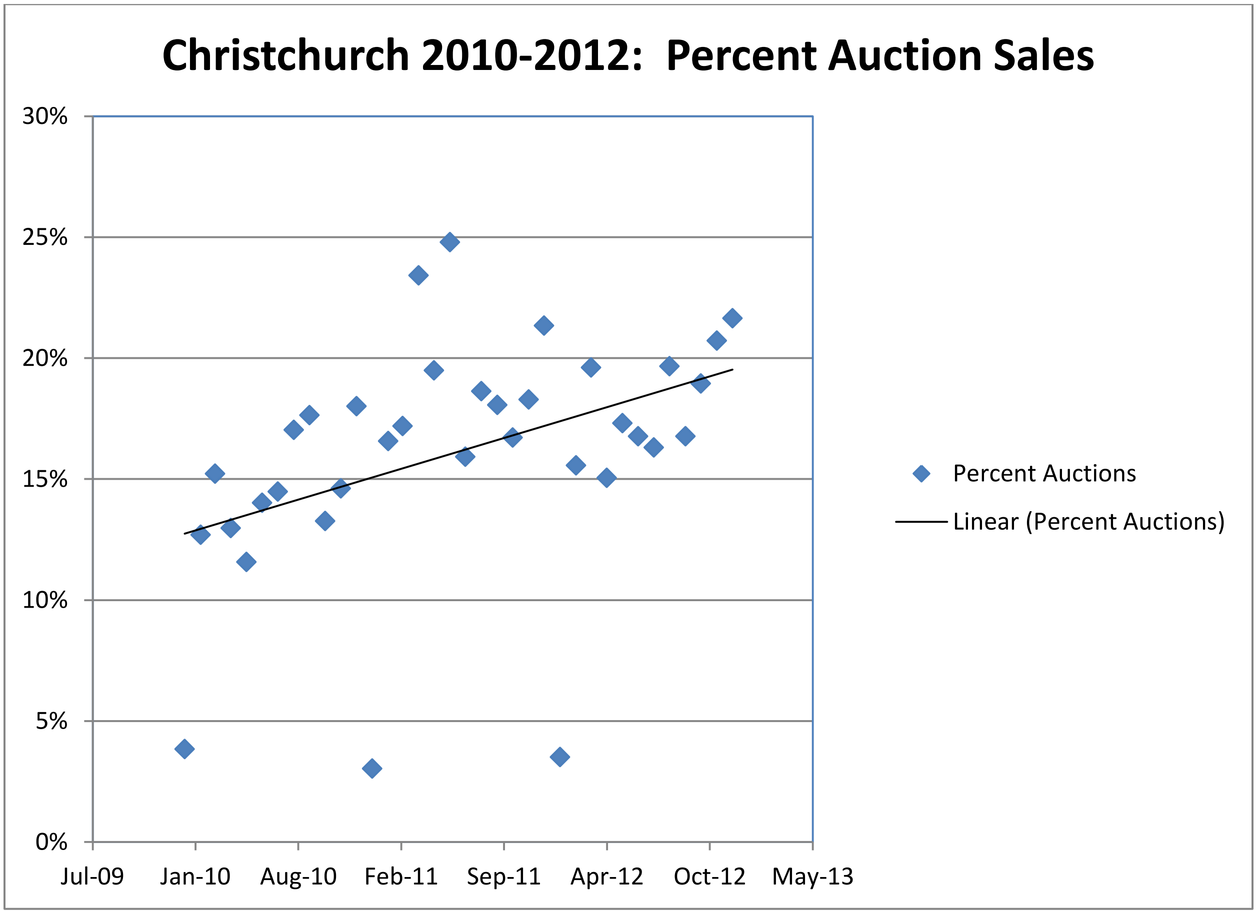
Prentice, D. (2005). Two Earthquake Damage Scenarios for the Wellington Region. Wellington, New Zealand: Opus International Consultants Limited, Wellington Office.

Skantz, Terrance R., and Strickland, Thomas H. "House Prices and a Flood Event: An Empirical Investigationof Market Efficiency." *The Journal of Real Estate Research* 2 (Winter 198-/), 75-83.

Speyrer, J. and Ragas, W. 1991. Housing Prices and Flood Risk: An Examination Using Spline Regression. *Journal of Real Estate Finance and Economics* 4, 395-407.

Vigdor, J. 2008. The Economic Aftermath of Hurricane Katrina", *Journal of Economic Perspectives* 22(4), 135-54.

Figure 1: Auction Use over Time



The figure above shows the percentage of all transactions that were auctions, including only transactions where method of sale was reported. The three very low data points represent January of each year and seem likely to be a seasonal effect.

Table 1A

Variable	N	Mean	Std Dev
sqft	17,609	1,577	722
pricesqft	17,609	250	238
Land_Area	12,248	0.069	0.082
Asking_Price	12,070	$ 211,603	$ 211,155
Sale_Price_Net	17,609	$ 379,383	$ 192,182
Bedrooms	17,558	3.05	0.80
age	17,609	40.5	27.3
GOOD	17,609	0.718	0.450
AVERAGE	17,609	0.265	0.441
POOR	17,609	0.011	0.102
AUCTION	17,609	0.111	0.314
FCLR	17,609	0.002	0.040
Negotiated	17,609	0.888	0.316

Table 1B

		Pre-Quake			Quake-Period			Post-Quake	
Variable	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev
sqft	4,461	1,553	689	4,473	1,594	690	8,675	1,581	754
pricesqft	4,461	241	65	4,473	242	64	8,675	$ 260	$ 332
Land_Area	3,113	0.072	0.151	3,112	0.07	0.04	6,023	0.07	0.03
Asking_Price	2,944	$ 232,340	$ 201,414	3,119	$222,213	$212,152	6,007	$ 195,931	$214,096
Sale_Price_Net	4,461	$ 360,434	$ 177,217	4,473	$374,956	$200,156	8,675	$ 391,409	$194,505
Bedrooms	4,434	3.02	0.80	4,462	3.0	0.8	8,662	3.1	0.8
age	4,461	41.1	27.2	4,473	38.2	27.1	8,675	41.3	27.3
GOOD	4,461	0.700	0.458	4,473	0.739	0.439	8,675	0.717	0.451
AVERAGE	4,461	0.277	0.448	4,473	0.244	0.429	8,675	0.269	0.443
POOR	4,461	0.011	0.105	4,473	0.012	0.109	8,675	0.009	0.096
AUCTION	4,461	0.085	0.278	4,473	0.117	0.321	8,675	0.121	0.326
FCLR	4,461	0.001	0.037	4,473	0.001	0.033	8,675	0.002	0.044
Negotiated	4,461	0.914	0.280	4,473	0.882	0.322	8,675	0.877	0.329

Table 2: Sale Price without Controls for Sales Method										
2A PreQuake				**2B QuakePeriod**				**2C PostQuake**		
Variable	Parameter Estimate	Standard Error	t Value	Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value
Intercept	11.85	0.02	673.0	11.79	0.02	652.5		11.85	0.04	337.9
time	-0.0032	0.00151	-2.1	0.003	0.001	4.7		0.0075	0.0010	7.48
sqft	0.0004	0.00001	66.8	0.0004	0.0000	76.5		0.0002	0.0000	48.02
Land_Area	0.0036	0.02266	0.2	0.916	0.091	10.1		1.3944	0.1066	13.08
age	0.0009	0.00015	6.2	0.0004	0.0001	2.8		-0.0010	0.0002	-6.22
GOOD	0.039	0.009	4.4	0.03	0.01	4.3		0.054	0.009	5.8
POOR	-0.064	0.029	-2.2	-0.08	0.03	-3.0		-0.101	0.032	-3.18
RANKING	0.084	0.003	26.3	0.08	0.00	27.0		0.102	0.003	30.9
Obs	3,113			4,619				4,516		
Adj Rsq	0.74			0.73				0.61		

Table 3: Effect of Sales Method on Price with Neighborhood Controls										
3A PreQuake				**3B QuakePeriod**				**3C PostQuake**		
Variable	Parameter Estimate	Standard Error	t Value	Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value
Intercept	11.86	0.02	675.8	11.80	0.02	655.4		11.89	0.03	342.2
time	-0.0040	0.0015	-2.7	0.0028	0.0006	4.7		0.0066	0.0010	6.7
sqft	0.0004	0.00001	65.8	0.0004	0.00001	75.5		0.0002	0.00001	47.3
Land_Area	0.0044	0.0224	0.2	0.9054	0.0900	10.1		1.3431	0.1052	12.8
age	0.0008	0.0001	5.5	0.0003	0.0001	2.2		-0.0011	0.0002	-7.0
GOOD	0.037	0.009	4.3	0.033	0.008	4.2		0.054	0.009	5.8
POOR	-0.068	0.029	-2.4	-0.073	0.026	-2.8		-0.091	0.031	-2.9
RANKING	0.082	0.003	26.0	0.073	0.003	26.4		0.097	0.003	29.8
FCLR	0.037	0.093	0.4	-0.179	0.064	-2.8		-0.263	0.093	-2.8
AUCTION	0.087	0.011	7.9	0.066	0.008	7.9		0.111	0.010	11.3
Obs	3,113			4,619				4,516		
Adj Rsq	0.74			0.74				0.62		

These two tables show the effect of adding action method of sale, distinguishing between distress sales (FCLR) and standard sales (AUCTION). In both specifications, neighborhood quality is measured by the prestige rankings from Dotzour (1998).

Table 4 Robustness Test: Neighborhood Dummies Replace Neighborhood Prestige Ranking											
4A PreQuake					4B QuakePeriod				4C PostQuake		
Variable	Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value
Intercept	12.23	0.03	368.7		12.15	0.02	584.3		12.25	0.04	323.5
TC2	-0.01782	0.01105	-1.6		0.0273	0.0107	2.6		-0.0053	0.0142	-0.4
TC3	0.00077	0.01269	0.1		0.0309	0.0130	2.4		-0.0638	0.0176	-3.6
time	-0.00292	0.00122	-2.4		0.0041	0.0005	8.8		0.0067	0.0008	7.9
sqft	0.00034	0.00001	64.2		0.0003	0.000004	74.1		0.0002	0.000004	45.4
Land_Area	0.02802	0.01845	1.5		1.3588	0.0752	18.1		1.6534	0.0963	17.2
age	-0.00078	0.00013	-5.8		-0.0014	0.0001	-11.5		-0.0023	0.0002	-15.1
GOOD	0.027	0.007	3.7		0.026	0.007	4.0		0.051	0.008	6.1
POOR	-0.063	0.024	-2.7		-0.063	0.021	-3.0		-0.028	0.027	-1.0
FCLR	-0.033	0.076	-0.4		-0.158	0.051	-3.1		-0.256	0.080	-3.2
AUCTION	0.034	0.009	3.8		0.019	0.007	2.9		0.075	0.008	8.8
SUBURB	Not reported				Not reported				Not reported		
Obs	3,112				4,618				4,515		
Adj Rsq	0.83				0.84				0.74		

Table 5: Effect of Stated Asking Price on Sales Price (Non-auctioned Properties Subsample)											
5A PreQuake					5B QuakePeriod				5C PostQuake		
Variable	Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value		Parameter Estimate	Standard Error	t Value
Intercept	11.90	0.02	649.6		11.82	0.02	625.0		11.97	0.04	323.0
time	-0.003	0.0015	-2.3		0.003	0.000602	5.0		0.006	0.001	5.9
sqft	0.0004	6.10E-06	64.5		0.0004	5.32E-06	73.2		0.0002	5.19E-06	42.3
Land_Area	-0.002	0.0218	-0.1		0.849	0.09275	9.2		1.379	0.113	12.3
age	0.001	0.0002	4.1		0.000	0.000137	1.1		-0.002	0.0002	-9.7
GOOD	0.038	0.0088	4.3		0.030	0.00811	3.7		0.051	0.010	5.2
POOR	-0.078	0.0303	-2.6		-0.078	0.02628	-3.0		-0.074	0.031	-2.4
RANKING	0.076	0.0033	23.4		0.073	0.00288	25.4		0.096	0.003	28.0
priced	-0.041	0.0068	-6.0		-0.033	0.00583	-5.6		-0.018	0.007	-2.4
Obs	2,784				3,966				3,854		
Adj Rsq	0.74				0.75				0.60		

Table 4 shows the effect of replacing the neighborhood ranking variable used in Table 3 with dummy variables for each of the suburbs included.

Table 5 utilizes the sub-sample of properties which were not sold at auction to assess the effect of stating an asking price (the variable "priced") on ultimate sales price.

Table 6: Effect of Stated Asking Price on Sales Price (Non-auctioned Properties Subsample)									
6A PreQuake				**6B QuakePeriod**			**6C PostQuake**		
Variable	**Parameter Estimate**	**Standard Error**	**t Value**	**Parameter Estimate**	**Standard Error**	**t Value**	**Parameter Estimate**	**Standard Error**	**t Value**
Intercept	11.90	0.024	489.9	11.85	0.025	482.3	11.78	0.043	275.6
time	-0.0040	0.0018	-2.2	0.0026	0.0008	3.4	0.0072	0.0012	5.9
sqft	0.0004	8.6E-06	42.7	0.0003	7.9E-06	43.8	0.0003	8.6E-06	39.6
Land_Area	0.4745	0.1435	3.3	1.2467	0.1755	7.1	1.1114	0.1800	6.2
age	0.0002	0.0002	1.0	-0.0005	0.0002	-2.6	-0.0009	0.0002	-4.7
GOOD	0.0299	0.0107	2.8	0.0289	0.0105	2.8	0.0243	0.0115	2.1
POOR	-0.1016	0.0368	-2.8	-0.0046	0.0382	-0.1	-0.0377	0.0363	-1.0
RANKING	0.0747	0.0040	18.9	0.0786	0.0037	21.1	0.0765	0.0042	18.4
StatedMin	0.0498	0.0231	2.2	0.0349	0.0171	2.0	0.0139	0.0087	1.6
Obs	1,432			1,934			1,628		
Adj Rsq	0.76			0.74			0.74		

Table 6 also utilizes the sub-sample of properties not sold by auction to assess the effect of characterizing the price as minimum above which offers would be considered.

Table 7: Effect of Heckman Correction on AUCTION Coefficient Estimate			
	Pre-Quake	**Quake**	**Post-Quake**
AUCTION (from Table 3)	0.087	0.066	0.111
AUCTION after Heckman correction	0.085	0.061	0.084
	Pre-Quake	**Quake**	**Post-Quake**
AUCTION (from Table 4)	0.034	0.019	0.075
AUCTION after Heckman correction	0.065	0.026	0.059

Table 7 shows the coefficients on the variable AUCTION before and after a Heckman correction for sample selection bias.