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Who cares? Future sea-level-rise and house prices

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Who Cares? Future sea-level-rise and house prices

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Abstract: Globally, the single-most observable, predictable, and certain impact of climate change is sea level rise. Using a case study from the Kapiti Coast District in New Zealand, we pose a simple question: Do people factor in the warnings provided by scientists and governments about the risk of sea-level rise when making their investment decisions? We examine the single most important financial decision that most people make – purchasing a home, to see whether prices of coastal property change when more/less information becomes available about property-specific consequences of future sea level rise. The Kapiti Coast District Council published detailed projected erosion risk maps for the district's coastline in 2012 and was forced to remove them by the courts in 2014. About 1,800 properties were affected. We estimate the impact of this information on home prices using data from all real estate transactions in the district with a difference-in-differences framework embedded in a hedonic pricing model. We find that the posting of this information had a very small and statistically insignificant impact on house prices, suggesting people do not care much about the long-term risks of sea-level rise as they do not incorporate these risks in their investment decisions.

JEL: Q54, R38

Keywords: House price, sea level rise, climate change, erosion

Carpe diem quam minimum credula postero
(Horace's *Odes*: Seize the day, put very little trust in the future)

1. Introduction

Globally, the single-most observable, predictable, and certain impact of climate change is sea level rise. "Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m….The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence)." (IPCC 2014, SPM p. 4). The current scientific consensus about future sea-level rise was also summarised by the IPCC (Intergovernmental Panel on Climate Change):

> "Global mean sea level rise will continue during the 21st century, very likely at a faster rate than observed from 1971 to 2010. For the period 2081–2100 relative to 1986–2005, the rise will likely be in the ranges of 0.26 to 0.55 m for RCP2.6 [best likely case scenario], and of 0.45 to 0.82 m for RCP8.5 [worst likely case scenario]….Sea level rise will not be uniform across regions.…About 70% of the coastlines worldwide are projected to experience a sea level change within ±20% of the global mean." (IPCC 2014, SPM p. 13).

Using a case study, we pose a simple question: Do people factor in the warnings provided by scientists and governments about the risk of sea-level rise when making their investment decisions? We examine the single most important financial decision that most people make – purchasing a home, to see whether prices of coastal properties change when more/less information becomes available about the property-specific consequences of future sea level rise (SLR).

In order to identify an empirical answer to this question, we use a unique case study from one local council in New Zealand – the Kapiti Coast District Council. In this case, the District Council produced detailed projected erosion risk maps (SLR-related) for the whole district's coastline and published it in 2012. This projected risk assessment was conducted for 50- and 100-year horizons and with and without coastal protection and management changes being implemented. Based on the findings of the assessment, the Council notified some 1,800 affected households that were placed in zones deemed to be at risk of erosion because of future sea-level rise, and this hazard risk information was placed on Land Information Memorandums (LIM) held by the council. These LIMs are made available to every property buyer, and it is standard practice that LIMs are examined by the buyer and their legal representatives during the purchase process.

Following the placement of this future risk information on the LIMs, substantial negative reactions by current owners of these properties ensued. Coast Ratepayers United, a local group of homeowners, was formed and fought to remove the hazard warnings from the LIMs. The group challenged through the courts the accuracy of the Council's analysis and the limited scope of public consultation. Reaching the High Court, the presiding judge ruled that while the council was within its legal rights to assess and note hazards, the lines had the 'potential to seriously affect the value and marketability of coastal properties in the district' putting 'millions of dollars at stake' and hence the process needed to be more 'clear, fair and balanced' (Haxton 2014). Following this decision, the council decided to remove the hazard lines from the LIMs and these maps were removed from online access.

Given the known timing of the posting of this information, and its subsequent removal, we can estimate the impact of this information on home prices. We use a difference-in-differences framework to measure if public disclosure coupled with notices placed on coastal properties were capitalized into the prices of affected residential properties, and whether this price effect ceased after the information was removed in 2014.

These questions, of course, are not relevant only for the residents of the Kapiti Coast (a coastal strip just to the North and West of the capital, Wellington). In 2006, 65% of the total population of New Zealand lived within 5 km of the country's coasts (Statistics NZ, 2016). The main concentrations of population in the low-lying coastal areas are in the densely populated urban settlements, and an estimated NZ$ 52 billion worth of building assets are exposed to coastal risk (NIWA 2015). As changes in values of residential properties on the coast may also affect the value of nearby properties and entire neighbourhoods, these questions have an impact on the home value of many New Zealanders, and of course, in many other countries.

2. Literature on Coastal Risks and Coastal Properties

2.1. Quantifying the damage from SLR

Not surprisingly, SLR has drawn the attention of researchers globally. With advances in methodologies and geo-spatial data, strategies for country-level and global scale estimation of the impact of SLR on existing assets have emerged (Sugiyama et al. 2008; Tol 2007; Tol et al. 2008). Although useful for framing a national approach to climate policy, such studies lack generalisability for estimating the costs of SLR at a local and the micro scales due to variations in geo-morphology as well as socioeconomics and politics.

The emergence of microeconomic research on the impacts of SLR has been rather slow, with studies primarily originating from North America. For example, Yohe et al. (1995) estimated the potential loss of land and built structures with aggregate property data for South Carolina. Following the method developed by Yohe et al. (1995), but using disaggregated property transaction data, Parsons and Powell (2001) estimated the cost of beach retreat in Delaware to the year 2050 to be around $291m (in USD valued in 2000). Michael (2007) considered the impact of increased storm surge flooding in Chesapeake Bay communities and found that damage from storm floods may be 28 times greater under a 2-foot SLR scenario. On the North Carolina coast the magnitude of future property value losses because of SLR varies with the location and level of development (Bin et al. 2011); while in Florida coastal inundation costs can reach $7b (Fu et al. 2016).

McAlpine and Porter (2018) look at flood risk in Miami and the way it is changing because of SLR. They find a small but statistically significant impact on property prices. However in the Miami case there is little chance that these properties will be abandoned given their very high values and, at least according to current law, they will be able to continuously remain insured through the U.S. National Flood Insurance Program (NFIP).

Hidano et al. (2015) use regression discontinuity design and seismic risk maps to similarly identify the price impact of SLR risk. They find a very small but statistically significant difference. Walsh et al. (2019) focus on the property value of protection from SLR in Chesapeake Bay in the United States. They find a significant and consistent loss in value associated with SLR risk, using a similar method to Hidano et al. (2015). None of these studies however capture the provision of readily accessible climate change risk information, which is the focus of the current paper.

An attempt to measure the 'average' or aggregate effect might be heterogeneous. Different agents could have, for example, different views about temporal discounting or may have a different awareness of the risk. In a recent study, Bernstein et al. (2018) estimated a 7% discount in home prices exposed to SLR with further evidence of deeper discounts among more 'sophisticated' buyers and sellers. Similarly, Baldauf et al. (2018) observed that differences in beliefs about SLR (climate change believers vs deniers) are reflected in house prices with properties in 'believer' neighbourhoods selling at a discount compared to 'denier' neighbourhoods.

2.2. *Quantifying the effects of flooding events on property prices*

A separate stream of research has investigated the effects of catastrophic natural hazards on house prices, showing robust empirical evidence that homeowners tend to adjust their perceptions of future risk (and consequently prices) in response to the occurrence of a disaster. In most studies, however, the effect of these catastrophic events on prices is fairly short-lived, with prices returning to their previous pre-disaster level after 2-3 years at most (e.g., Atreya et al. 2013). Sometimes, the effect of catastrophic events is even measured only in months (Deng et al. 2015). Researchers have examined both the impact on prices in the same location in which the catastrophic event has occurred, but in undamaged properties (Deng et al. 2015); and in locations that are perceived to be similar in their risk profile but that were not directly affected by the catastrophe (e.g., Timar et al. 2018a, 2018b)

In an efficient market with homeowners well-informed of risks, fully insured properties should trade at a discount equal to the capitalised value of insurance premiums (Bin and Landry 2013). A priori, if the occurrence of the disaster does not provide any new information (i.e., it was just an ‘unlucky’ draw from a known independent distribution) it should not have any impact on prices. Conversely, if owners underestimated the risks and now face increasing insurance costs (i.e., insurers similarly underestimated the risk), reductions in property value can be substantial.

Thus, the empirical evidence from this literature suggests that such flood risks tend to lead to discounted property prices (Rajapaksa et al. 2016). Public disclosure of risks, even in the absence of an actual event, has been shown to discount prices. For example, a study of flood hazards in Auckland, New Zealand, found that properties in the flood plain were discounted by 2.3% when their risk profile was made available to the public (Samarasinghe and Sharp 2010).

Our study, in contrast, is concerned with the effect of new information about future projected climate-change risk on the dynamics of coastal house prices, rather than of past events or existing risks. It is, to our knowledge, the only study to focus on this question.

2.3. Challenges in identifying the importance of new information about SLR

Indisputably, coastal hazards and coastal amenities are spatially correlated and highly dependent. There exists a trade-off between hazards and amenities offered by living close to the coast. Some studies of coastal areas point to the presence of a price premium rather than the expected discount, as these estimations fail to account for appreciable coastal amenities such as sea views and accessibility to the coast (Beltran et al. 2018). A few studies account for such competing effects and therefore provide improved more genuine estimate of the inundation risk discount suffered by residential properties due to SLR . Bin et al. (2008) suggest that incorporating GIS-based view measures (view-scope and distance to coast) helps disentangle coastal risk from coastal amenities. In the presence of the view amenities, coastal risk devalued properties in North Carolina beach communities by approximately 11%. Likewise, studying the state of Queensland in Australia, Rambaldi et al. (2014) isolated inundation risk discount in house prices taking into account views and proximity to the ocean and waterways.

Previous findings also suggest that any discount associated with proximity to the ocean and SLR is not uniform and varies with location and owners' beliefs about climate change, demonstrating the importance of micro-level research. Factors such as sea views and recreational access potentially mask or override property value reductions. Furthermore, rising property markets and expectations of future capital gains can potentially desensitise prospective buyers of SLR risks (DEFRA 2009).

Yet, there is no published empirical evidence to determine if official information about future coastal hazard risk is reflected in house prices. The question here is not what is the price discount associated with being within the erosion-risk line, but rather what is the price impact of that information, once and when it is provided to prospective homebuyers and sellers. This is an important policy question. Attempts by local authorities to notify residents of hazards remain controversial and often draw backlash and anxiety from affected households. Owners typically cite anecdotal evidence on the negative impacts on property value following public disclosure of risks and are therefore often vehemently opposed to public disclosure.

While public opposition to the supply of risk information roars in the background, assessments by two regional councils in New Zealand argue that coastal hazards do not affect property values. Furthermore these local government authorities insist that broader property market and economic factors far outweigh any stigma that may be perceived by any public warning about hazard risk (Environmental Management Group 2008; Environment Waikato 2006).[1] With these opposing views in mind, our aim is to assess the crux of the debate: does public disclosure of hazard risks impact house prices?

3. Study methods

We use a difference-in-difference (DID) regression method estimated within a hedonic model of property sale prices. This DID design allows us to identify the effect of public disclosure of coastal hazard risk on property prices. Properties that are located in the reported coastal hazard zones are the treatment group and properties in the Kapiti Coast District but outside the reported coastal hazard zones are the control group. Because both groups are located in the same area, their property value is influenced by similar contemporaneous factors. In addition, we are able

[1] Since 2000 and leading up to the GFC, New Zealand property market has experienced a surge in demand for housing, when house prices increased in real terms by 77% (Kendall 2016). The most recent rise in house prices began in 2012, surpassing the peak of the previous property cycle.

to control for coastal amenities, specifically their distance from the coast and the existence and quality of their 'sea-view'. Two other factors assist us in the identification. First, the hazard lines were known to the public for a well-defined period of time (September 2012 through October 2014). Second, the lines were not drawn at equal distance from the ocean along the Kapiti coast, further allowing us to identify the price difference associated with the hazard lines and differentiate it from amenities associated with proximity to the coast.

This approach allows us to extract the effect of reported hazard risk on property price from other variables. The DID model is designed as follow:

$$GrossPrice_i = \beta_0 + \beta_1 Post_i + \beta_2 Affect_i + \beta_3 Post_i Affect_i + \beta_k X_i^k + \sum_{c=1}^{C} \beta_c D_i^c + \varepsilon_i$$

[1]

In the specification, the variable $Affect_i$ takes value of 1 if the property (*i*) is located inside the coastal hazard lines and 0 otherwise. The control group ($Affect_i = 0$) are properties outside the hazard areas. $Post_i$ is a binary variable equal to 1 if the transaction sale occurs after the public disclosure date of the coastal erosion prediction maps (from September 2012 onward). The interaction term between $Affect_i$ and $Post_i$ is the difference-in-difference treatment effect showing how the public disclosure of hazard risk affected the local property price. The natural log of sale price is used as the dependent variable $GrossPrice_i$.

The hedonic function is estimated in the log-linear form with two types of explanatory variables. The specification includes house-specific characteristics, *k*, and location as control variables (X_i^k).[2] They are: building floor area, site area, internal and external condition, type of external cladding, extent of sea view, land contour, and elevation. All continuous variables

[2] Because the Kapiti Coast area has not experienced any large/moderate disaster event in recent times, we do not control for any physical damage to properties associated with such events. There are very few insurance claims related to hydro-meteorological hazards in the last 30 years in the Kapiti Coast district (Fleming et al. 2018).

are converted to natural logarithm form. In addition, census-area unit, deprivation index, quarter sold, and vintage (decade of construction) fixed effects (D_i^c) are included to capture the time-invariant characteristics that may affect all the properties across different groups.

4. Study area and Data

4.1. Kapiti Coast study area

The Kapiti Coast is a coastal area in the south-west corner of the North Island of New Zealand (see Figure 1). In 2012, Kapiti Coast District Council (KCDC) was preparing for a new District Plan. The main focus for KCDC and local community was how to respond to coastal erosion risks in the coming decades (KCDC 2012). The management of the risk was perceived as more urgent with already-occurring sea level rise and other future potential effects of climate change. Policy 24 in the NZ Coastal Policy Statement of 2010 states: "*[the policy statement] requires councils to identify areas in the coastal environment that are potentially affected by coastal hazards … over at least 100 years … including the effects of climate change."*

As a result, a detailed coastal hazard assessment was carried out by Dr Roger Shand of Coastal Systems Limited (CLS), an experienced coastal hazard expert, and completed by August 2012. This report followed best-practice guidance and was peer-reviewed by other experienced coastal engineers and scientists. It defined a series of potential 'future shorelines' based on managed and unmanaged scenarios with 50- and 100-year planning time frames (Shand 2012). The projected shorelines take into account both current and future risks.[3]

The coastal erosion projections were conducted based on detailed analysis of current and historic data (KCDC 2012). The collected data included past coastal hazard studies in the region, historic aerial photographs (1940s to present), cadastral surveys (1890s to present) and

[3] Current risks are storm erosion and catch-up erosion (after the loss of protection work for unmanaged scenarios). Future risks are the effect of projected sea-level rise and continuation of existing erosion trends.

projections of future climate change and sea-level rise from the Ministry for the Environment guidelines (2008).

The hazard risk information was then put on affected property's Land Information Memorandums (LIMs) and notification letters were sent to affected property owners on 25th August 2012 as required by the Local Government Official Information and Meeting Act.[4] The coastal LIMs contained neighbourhood maps of shoreline projections to inform people about the hazard risk in their neighbourhood. According to the KCDC's statistics, coastal erosion would endanger up to 1,000 properties within 50 years, and 1,800 properties would be at risk within 100 years. The current capital value of affected properties was estimated to be NZ$ 1.6 billion (KCDC 2012).

The public disclosure of hazard information led to an immediate public and media outcry. A high-profile interest group - Coast Ratepayer United - was formed to prevent the dissemination of this report of coastal hazard lines and challenge the assessments with public pressure applied onto elected district council members. In 2013, coastal residents requested a High Court Judicial Review and sought to exclude the coastal hazard information from LIMs report. In December 2013, Judge Joe Williams ruled that under Section 44A(2)(a) of the Local Government Official Information and Meetings Act 1987: "*KCDC had no choice but to note coastal hazard information, contained in the Shand Report, on LIMs.*"

The judgment found the KCDC had no discretion in this regard and was obligated to make the information available in a clear manner (KCDC 2013a). However, the judge also ruled that: "*The lines were starkly simplistic as a summary of the complex Shand information and have the potential to seriously affect the value and marketability of coast properties*."

[4] KCDC (2013b) provides a detailed timeline of consultation and communication activities before and after the release of coastal hazard line information in August 2012.

Due to the pressure from the Coast Ratepayer United group, KCDC decided to remove all coastal erosion line maps and related explanatory text from LIMs in October 2014 (KCDC 2014). In November 2017, the council released a new Proposed District Plan with no erosion hazard information or provisions in it.

Figure 1 illustrates the four coastal erosion lines with an example from a settlement in Kapiti Coast called Waikanae. These hazard lines represent different scenarios for 50-year and 100-year projection periods. These scenarios indicate what is expected to happen due to coastal inundation caused by storm events and shoreline retreat caused by coastal erosion. The 50- and 100- year natural line maps presume that existing seawalls are not repaired and eventually erode themselves.[5] While the 50- and 100- year managed line maps assume the management/maintenance of current public seawalls/inlets and other protection works.

4.2 Property transactions and other data

This study analyses sales transactions of freestanding houses (excluding flats and apartments) sourced from CoreLogic for Kapiti Coast District Council from Q1 2009 through Q1 2018. Transactions were excluded from analysis if they were suspected to include data entry errors. Specifically, houses were removed if the floor area was less than 30 square metres or over 500 square metres, if lot size was over 2,000 square metres, or had any missing data. Also transactions were deleted if flagged as outliers (standardised residuals beyond three standard deviations), had leasehold rather than freehold interests or were explicitly coded as not reflecting an arm's length transaction (e.g. non-market sales price, related party sales, etc).

As the home sales transaction dataset from CoreLogic does not include certificate of title unique identifiers nor does it provide full address information (only street name and an

[5] According to the NZ Coastal Policy Statement and Wellington Regional Policy Statement, the KCDC does not support hazard protection structures such as seawalls because they are unlikely to provide a long-term solution to coastal erosion in Kapiti Coast district.

indication of whether the property's street number was odd or even), a series of steps were required to associate each sales transaction with its respective land title, which is subject to hazard warnings stated on the property's LIM.

Land title information is sourced from Landonline, the system used to manage New Zealand's land information. It is comprised of numerous spatial and attribute databases that comprise the country's cadastral (land title and property ownership) and topographic information. Data held by Landonline can be freely accessed online at https://data.linz.govt.nz/.[6]

The first objective is to identify title transfers in the Kapiti Coast District that have occurred within the study timeframe (2009 through 2018). Consideration must be given to the fact that there is a time lag between a property's sales date (when a willing buyer and seller agree to specific terms and conditions and execute a conditional sale and purchase agreement) and its settlement date when the title is transferred, within Landonline, from the seller to the buyer. The elapsed time between sale date and settlement (transfer) date averages 11 weeks but ranges from zero (same day) to over a year. Therefore title transfers that have occurred between Q1 2009 through Q4 2018 are analysed to take into account the duration between sale and transfer.

With transferred titles identified the next step is to remove from the dataset of non-market, related party transfers (e.g. homeowners transferring title to a family trust). Title owner names are acquired from Landonline's 'title memorial text' dataset and used to identify related parties through comparisons of buyer and seller names. When a match is found the transfer is assumed to involve related parties and is removed from consideration. The remaining non-related party, or market, title transfers are then associated with their respective land titles using Landonline's 'title instrument title' dataset.

[6] For the purposes of linking sales transactions to their respective land titles, several relevant Landonline databases must be acquired and manipulated including 'street addresses', 'property titles', 'title memorial text' and 'title instruments'.

Land titles that experienced at least one legitimate, market transfer are downloaded from the LINZ Data Service as a polygon GIS shapefile theme. Through use of geographic information system (GIS) software these land title polygons are spatially joined to Landonline's street addresses (point theme). This geoprocessing operation appends the LINZ database of title transfers with the full street address of each land title that was transferred (sold) within the study timeframe.

With full addresses linked to land titles, sales transaction records are then married to their respective land title transfer record using the available partial street address information, land parcel size (available in both sales transactions and land title databases) and sales/settlement (transfer) dates. This enables us to ascertain the exact land title associated with each of the 8,436 freestanding home sales transactions that occurred within the Kapiti Coast District during the study timeframe.

The district's land titles polygons were overlaid with drawing exchange format (DXF) line themes representing each of the four modelled 'future shorelines'. These DXF files were provided by Dr Roger Shand for use in this study. Figure 1 provides an illustration of how these line themes are used to code land titles as being affected or not.

[Insert Figure 1 here]

The period in which the hazard maps appeared on LIMs (September 2012 through October 2014) does not seem out of the ordinary for the affected properties in terms of the number of sales when plotted against the control group and for the whole period (2009-2017) as shown in Appendix Figure 1. As for all other properties, there was a slowdown in sales that started in 2006 and hit a trough in 2008; this was the local manifestation of the Global Financial Crisis. Volume of residential sales did not recover until several years later, in 2011, albeit never reaching the peaks of the previous property cycle. Similar observations are had when we examine the average (mean) sale price (Appendix Figure 2) for all the sub-samples – properties in the 50-year-managed, 50-year-unmanaged, 100-year-managed, 100-year-unmanaged, and the control group (properties further away or higher up from the coast).

Two additional observations are worth making. First, it was reported in the media that following the successful court challenge and removal of hazard warnings from LIMs, many owners of affected properties subsequently sold their houses (e.g., Cann 2017). This however, is not the case. The volume of transactions of affected properties in the months following the removal of hazard lines from LIMs, in October 2014, is well within the normal range; any uptick merely correlates with a more general uptick in property sales across the district. Second, the observation that the market for affected properties correlates closely with the wider property market suggests that, looking at the number of property transactions, there is most likely no selection problem. The decision whether to sell or not appears unrelated to the placement of erosion risks on LIMs in September 2012 or to their removal in October 2014.

Table 1 reports the summary statistics of key variables considered in our study. The average property sale price was NZ$384,000. Properties in control groups (A and C) were sold at 40 – 45% lower price, compared to properties in treated groups (B and D)[7]. This trend arises from the premium for the coastal amenities, such as beach access and uninterrupted sea views. The gross sale price increased more over time in the treated groups. The building floor area and site area are very similar across the control and treatment groups. Mean floor areas range from 154 to 157 m^2 while mean site areas fall into a tight cluster between 765 to 792 m^2.

Regarding property interior condition there are 17% properties coded as good quality and 5.8% reported as poor interior quality. Houses in the treated groups are more likely to have

[7] In the descriptive statistics table, the treated group includes all the residential properties that fall within the four coastal hazard lines.

poor interiors (13%). The exterior quality for most properties (63%) of both groups is coded as being in good condition. In addition, houses in the treated groups tend to be on steep land and have superior sea views than houses in the control groups.

[Insert Table 1 here]

5. Results

Table 2 presents the results of the DID estimation for the four coastal hazard scenarios. The models achieve a reasonable fit, with adjusted R^2 ranging between .771 and .774. All of the house-specific and location control variables are estimated with the expected signs and are statistically significant. Coastal amenities, such as sea views and proximity to the coast, positively influence the price. While a property that enjoys a wider sea view will receive a higher sale price, positioning further away from the coast does not command as much benefit from the same appreciable water view.

As noted before, we consider the period in which 'treatment' took place as the one after the announcement of Coastal Erosion Hazard Risk report and lodgement of hazard warnings on affected properties' LIMs in September 2012. As such, the main coefficient of interest is the difference-in-difference coefficient – *post*affected* – presented in the Table 2. We find that public disclosure and the presence of coastal erosion risk on a property's LIM report has no statistically significant effect on house prices, albeit having a negative sign. This is contrary to our expectation and popular opinion that public knowledge of future risks of sea level rise would cause the affected properties to be discounted.

Across the four estimations, the largest (yet not significant) effect is observed among properties that fall within the 50-year managed scenario and is estimated to be a negative 5.9% (column

4, table 2)[8]. As these properties would be 'the first to go' having the highest risk of exposure to coastal inundation and erosion, this is to be expected. It appears that buyers of waterfront properties are more aware of the coastal hazard risks, but the effect is still small and imprecisely identified.

[Insert Table 2 here]

In addition to this benchmark specification, we estimate three alternative specifications (see Appendix Tables 1-3). In the first specification, we use the sale price per squared-meter as dependent variable in the regression. In the second, we estimate the same equation as in Table 2, but use the 'post' period as the period in which the risk warning was appended to the LIM (only September 2012 to October 2014). In the third iteration (Appendix Table 3), we only estimate the price of land, rather than the aggregate price of the property (which includes both the price of the land and the price of the dwelling). For the long-term horizons of the scenarios we examine (50-100 years), a large portion of property value comes from the value of the land (as the dwelling depreciates eventually becoming obsolete). We hypothesize that coastal erosion risks may therefore mostly affect the sale price through changing the valuation of the land. We separate the price of the land by deducting, from the sale price, the estimated value of the dwelling (see Appendix A for explanation of land value estimation). The results for all three alternative specifications, as shown in the appendix, are very similar to the benchmark regressions results. In none of the alternative specifications the estimates of the difference-in-difference effect is statistically significant. Similarly, the coefficient for the 50-year managed risk zone (the highest risk) shows the most decline in sale prices, though still a statistically insignificant one.

[8] In this regression set, we apply robust standard error to control for heterogeneity in the error term. When we exclude this option, the treatment coefficient in column 4 is statistically significant at the 10% level.

Next, we examine effects of coastal hazard risk on property prices over time by estimating annual regressions for each hazard group.[9] The results are shown in Figure 2. We observe that the coefficients of the $Affect_i$ is consistently above 0 (ranging between 0.1 and 0.2). Only for the 50-year managed group, the effect briefly deeps below 0 in 2014. However, due to the confidence intervals, this effect is statistically insignificant. Overall, given the known hazard risks, buyers are still willing to pay the same premium for these coastal properties, and appear to largely ignore the new information they received in 2012. In short, the erosion risk information being placed in the LIM reports seemed to have had little effect on property pricing.

[Insert Figure 2 here]

We also estimated spatial regression models to control for the spatial dependencies in the pricing of properties (i.e., property prices are affected by prices of property transactions in the immediate neighbourhood; see Appendix B for details of the specifications). Appendix table 4 provides these results. Supporting the above findings, we find that the effect of the hazard information is insignificant across different models, specifications and across treated groups. The estimated spatial autoregressive (ρ) and autocorrelation (λ) coefficients are statistically significant; and the sale price of a property is positively influenced by neighbouring properties' sale prices.

6. Conclusions

One interpretation of Horace's *carpe diem* full dictum is not hedonistic; he asks his readers not to ignore the future and not to trust that everything is going to fall into place without deliberate action. Our evidence seems to suggest that rather than heeding that second part of

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[9] The $Post_i$ variable and interaction term are excluded in these specifications.

Horace’s counsel, the buyers of homes on the Kapiti Coast are ‘seizing the day’ and largely ignoring the future risks to their properties.

In New Zealand, the average time that a family owns a property is 6 years (Quotable Value 2012). As such, it might not be that surprising that prospective buyers are ignoring these long term risks. On the other hand, this assumes that future buyers will continue to ignore this risk so that selling later will not involve a significant loss, not unlike a scheme that Charles Ponzi would have approved. The evidence presented here suggested that this is indeed the case.

It might be the case, however, that only some people are ignoring these risks, and given the characteristics of real estate markets, the number of people ‘who care’ is not yet enough to be observable in a relatively limited geographical area (see Bakkensen and Barrage 2017). The evidence from elsewhere suggests that people do consistently ignore these types of risks until they became salient through some external event. Storey and Noy (2017) suggest that such an external event might be a strong storm surge—a disaster—that destroys a significant number of properties somewhere (maybe elsewhere in New Zealand) or a coordinated decision by private insurance companies or the government to stop insuring this erosion/storm-surge hazard. Whether, or when, that actually happens is, of course, impossible to predict.

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Table 1

Summary statistics of key variables at property level

	A. Pre_Control (n=2,245)	B. Pre_Treated (n=178)	C. Post_Control (n=5,614)	D. Post_Treated (n=399)	Overall (n=8,436)
Gross sale price (NZ$)					
Mean (SD)	363,000 (119,000)	515,000 (236,000)	377,000 (136,000)	541,000 (257,000)	384,000 (148,000)
[Min, Max]	[47,000, 1,200,000]	[170,000, 1,300,000]	[20,000, 1,220,000]	[125,000, 1,620,000]	[20,000, 1,620,000]
Decade of construction					
1900	8 (0.4%)	1 (0.6%)	12 (0.2%)	1 (0.3%)	22 (0.3%)
1910	7 (0.3%)	2 (1.1%)	22 (0.4%)	5 (1.3%)	36 (0.4%)
1920	37 (1.6%)	6 (3.4%)	75 (1.3%)	17 (4.3%)	135 (1.6%)
1930	31 (1.4%)	8 (4.5%)	72 (1.3%)	30 (7.5%)	141 (1.7%)
1940	69 (3.1%)	9 (5.1%)	156 (2.8%)	25 (6.3%)	259 (3.1%)
1950	231 (10.3%)	24 (13.5%)	613 (10.9%)	44 (11.0%)	912 (10.8%)
1960	274 (12.2%)	20 (11.2%)	646 (11.5%)	62 (15.5%)	1002 (11.9%)
1970	357 (15.9%)	29 (16.3%)	835 (14.9%)	62 (15.5%)	1283 (15.2%)
1980	358 (15.9%)	37 (20.8%)	1063 (18.9%)	64 (16.0%)	1522 (18.0%)
1990	326 (14.5%)	17 (9.6%)	816 (14.5%)	49 (12.3%)	1208 (14.3%)
2000	414 (18.4%)	8 (4.5%)	838 (14.9%)	12 (3.0%)	1272 (15.1%)
2010	56 (2.5%)	2 (1.1%)	283 (5.0%)	3 (0.8%)	344 (4.1%)
Floor area (m2)					
Mean (SD)	157 (63.0)	155 (68.9)	154 (61.2)	157 (70.2)	155 (62.3)
[Min, Max]	[30, 450]	[40, 380]	[30, 470]	[30, 400]	[30, 470]
Site area (m2)					
Mean (SD)	792 (255)	780 (242)	769 (261)	765 (255)	775 (259)
[Min, Max]	[261, 1,980]	[358, 1,820]	[214, 1,990]	[313, 1,850]	[214, 1,990]
Good interior quality					
Yes	402 (17.9%)	35 (19.7%)	921 (16.4%)	74 (18.5%)	1,432 (17.0%)
Poor interior quality					
Yes	118 (5.3%)	24 (13.5%)	298 (5.3%)	52 (13.0%)	492 (5.8%)

Good exterior quality					
Yes	1,406 (62.6%)	101 (56.7%)	3,635 (64.7%)	227 (56.9%)	5,369 (63.6%)
Poor exterior quality					
Yes	41 (1.8%)	6 (3.4%)	93 (1.7%)	10 (2.5%)	150 (1.8%)
Steep land					
Yes	90 (4.0%)	21 (11.8%)	216 (3.8%)	40 (10.0%)	367 (4.4%)
Crosslease 2 owners					
Yes	68 (3.0%)	10 (5.6%)	335 (6.0%)	33 (8.3%)	446 (5.3%)
Crosslease 3+ owners					
Yes	12 (0.5%)	3 (1.7%)	79 (1.4%)	8 (2.0%)	102 (1.2%)
Slight sea view					
Yes	88 (3.9%)	23 (12.9%)	210 (3.7%)	56 (14.0%)	377 (4.5%)
Moderate sea view					
Yes	85 (3.8%)	45 (25.3%)	168 (3.0%)	108 (27.1%)	406 (4.8%)
Wide sea view					
Yes	50 (2.2%)	48 (27.0%)	87 (1.5%)	89 (22.3%)	274 (3.2%)

Table 2

LHS variable- Log gross sale price - Affected Period 2012 – 2017

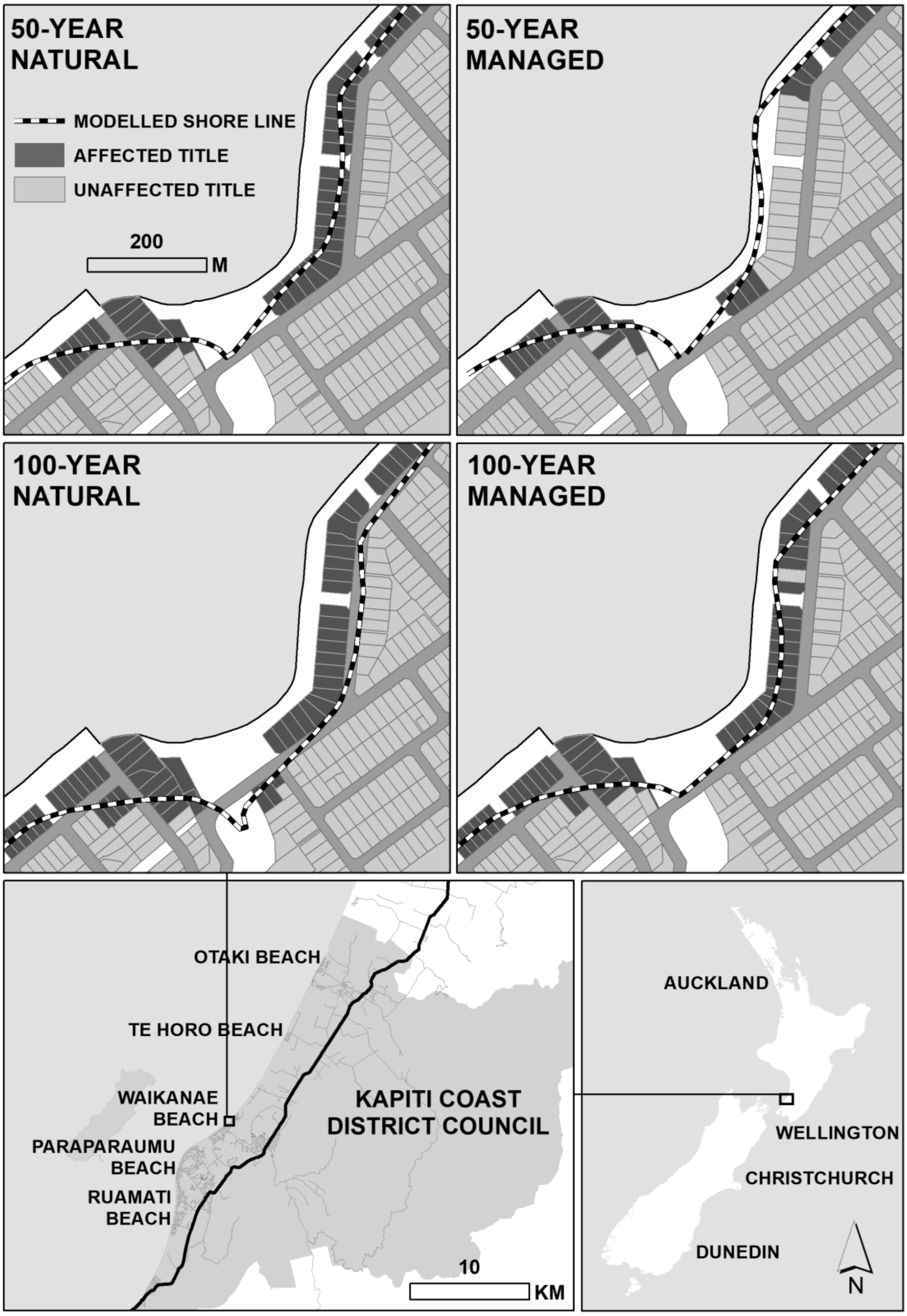
	(1)	(2)	(3)	(4)
	100yr natural	**100yr managed**	**50yr natural**	**50yr managed**
Affected	0.121***	0.140***	0.135***	0.101***
	(0.0139)	(0.0148)	(0.0176)	(0.0283)
Post disclosure	-0.0139	-0.0145	-0.0161	-0.0155
	(0.0157)	(0.0157)	(0.0156)	(0.0157)
Post*Affected	-0.00183	-0.0145	-0.00660	-0.0594
	(0.0206)	(0.0223)	(0.0294)	(0.0527)
Floor area	0.00395***	0.00394***	0.00395***	0.00398***
	(0.000170)	(0.000170)	(0.000171)	(0.000173)
Site area	0.000206***	0.000209***	0.000201***	0.000202***
	(0.0000346)	(0.0000346)	(0.0000346)	(0.0000348)
Good interior	0.0317***	0.0316***	0.0318***	0.0307***
	(0.00614)	(0.00614)	(0.00612)	(0.00614)
Poor interior	-0.0352***	-0.0344***	-0.0340***	-0.0305***
	(0.0113)	(0.0113)	(0.0113)	(0.0114)
Good exterior	0.0459***	0.0468***	0.0476***	0.0501***
	(0.00544)	(0.00542)	(0.00543)	(0.00542)
Poor exterior	-0.133***	-0.132***	-0.132***	-0.135***
	(0.0219)	(0.0219)	(0.0219)	(0.0220)
Cross lease (2 shares)	-0.0563***	-0.0558***	-0.0574***	-0.0557***
	(0.00838)	(0.00838)	(0.00840)	(0.00845)
Cross lease (3+)	-0.114***	-0.116***	-0.117***	-0.110***
	(0.0167)	(0.0167)	(0.0166)	(0.0170)
Slight sea view	0.387***	0.366***	0.435***	0.489***
	(0.0487)	(0.0489)	(0.0468)	(0.0481)
Moderate sea view	0.623***	0.602***	0.663***	0.757***
	(0.0487)	(0.0487)	(0.0490)	(0.0520)
Wide sea view	0.637***	0.607***	0.647***	0.775***
	(0.0496)	(0.0501)	(0.0495)	(0.0501)
Slight view *Distance	-0.0542***	-0.0510***	-0.0609***	-0.0688***
	(0.00773)	(0.00775)	(0.00752)	(0.00769)
Moderate view *Distance	-0.0817***	-0.0787***	-0.0865***	-0.0995***
	(0.00812)	(0.00813)	(0.00817)	(0.00856)
Wide view *Distance	-0.0784***	-0.0743***	-0.0789***	-0.0961***
	(0.00727)	(0.00733)	(0.00730)	(0.00746)
Constant	12.22***	12.21***	12.22***	12.21***
	(0.145)	(0.145)	(0.144)	(0.147)
Observations	8,436	8,436	8,436	8,436

Adjusted R^2	0.774	0.774	0.773	0.771

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Figure 1

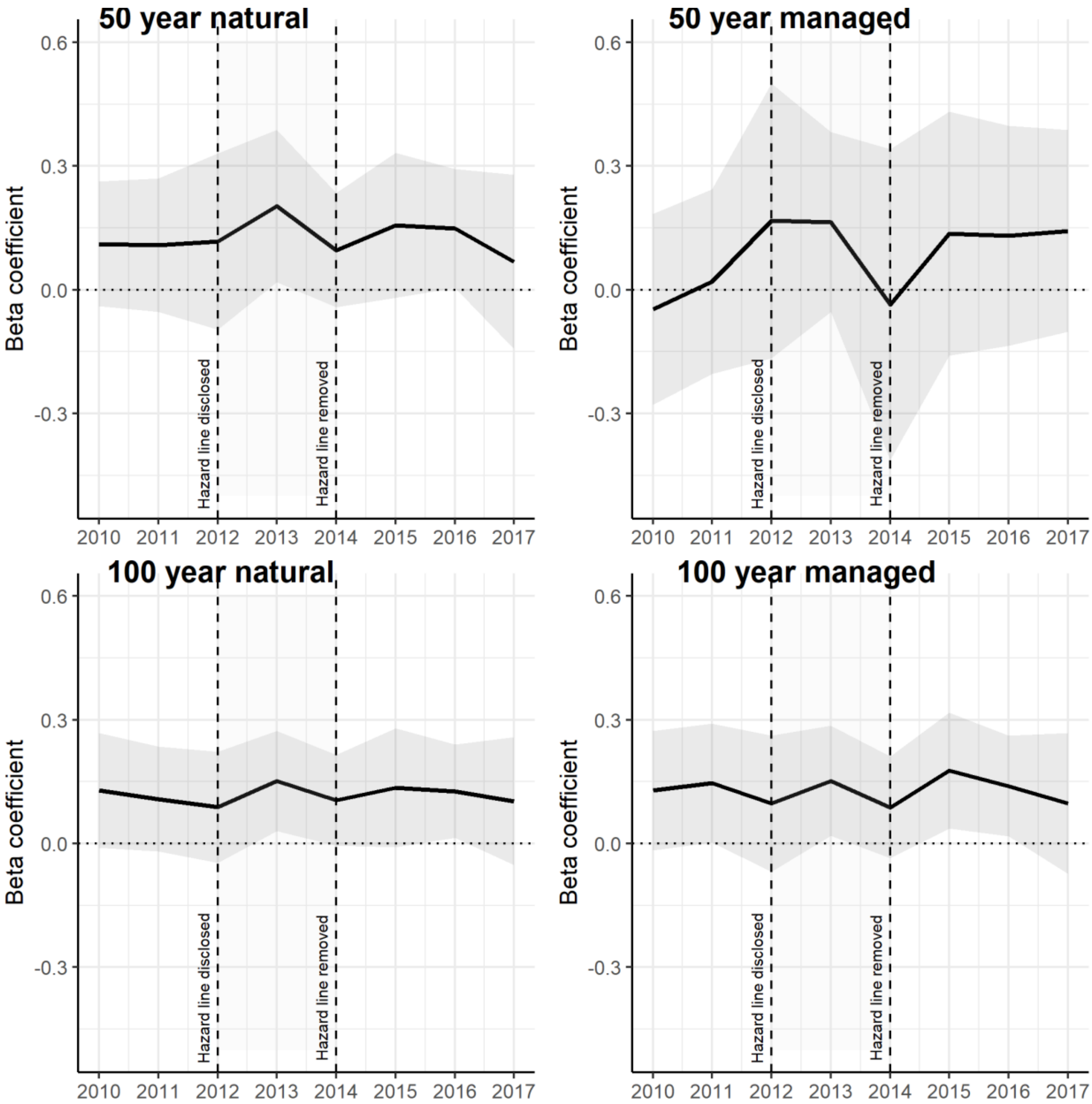
Study area location and coastal erosion scenarios



(There are 4 classifications, corresponding with the 4 coastal hazard risk lines, as presented in Figure 1, with an example from Waikanae. The number of treated observations in each specification are 577 (50 yr nat), 521 (50 yr managed), 347 (100 yr managed) and 130 (100 yr natural) out of 8,436 sale transactions between 2009-2017.)

Figure 2

Effect of coastal hazard risk on property price over time



(Note: the 95% confidence interval is shown as the grey-coloured ribbon.)

Appendix A: Methodology - Land sale price

We have: $Land\ price_i = Gross\ price_i - Dwelling\ price_i$

Given i is an individual property transaction. However, we do not observe the dwelling sale price for each transition. We estimate the $Dwelling\ price_i$ variable using Quotable Value (QV) rated value for each property. The QV is the assessed value of the property that is then used for assessing property taxes, and is frequently used as an indicator of possible price during house sales; it is provided separately for the value of the land and the dwelling. It is computed as follow:

$$Dwelling\ price_{it} = QV\_Dwelling\ value_{ir}\ \frac{Coefficient_i^{sale\_year(t)}}{Coefficient_i^{rate\_year(r)}} \qquad [A1]$$

The sale year (*t*) is frequently different from the year in which the property was assessed (QV property assessments are usually done every three years). We therefore convert the dwelling price to year (*t*) using the coefficients of the sale year (*t*) and QV rated year (*r*) dummies from our hedonic regression model.

Appendix B: Methodology - Spatial regression

We implement three different spatial regression models including Spatial Autoregressive Model (SAR), Spatial Error Model (SEM) and Spatial Autocorrelation Model (SAC). We employ spatial panel Maximum Likelihood estimation for the set of regression models with robust-standard error as described below.

(SAR) $$Y_i = \alpha + \rho W Y_i + \beta X_i + \varepsilon_i \qquad [A2]$$

(SEM) $$Y_i = \alpha + \beta X_i + \vartheta_i \quad \text{where} \quad \vartheta_i = \lambda W \vartheta_i + \varepsilon_i \qquad [A3]$$

(SAC) $$Y_i = \alpha + \rho W Y_i + \beta X_i + \vartheta_{i,t} \quad \text{where} \quad \vartheta_{i,} = \lambda W \vartheta_i + \varepsilon_i \qquad [A4]$$

In these models, there are two possible types of interaction effects among units: endogenous spatial interaction effects among the dependent variable (WY_i) and spatial interaction effects among the error terms ($W\vartheta_i$). The parameter ρ is the spatial autoregressive coefficient and λ are the spatial-response coefficients. W is the non-negative spatial weighting matrix ($N \times N$). It describes the spatial structure of the dependence between property locations in the sample. Here, we employ the inverse distance weighted matrix which is row-standardized. The elements ω_{ij} of matrix W show whether the properties i and j are spatially connected. We have $\omega_{ij} = {}^{1}/_{d_{ij}}$ for neighbouring properties given d_{ij} is the distance between properties i and j, otherwise $\omega_{ij} = 0$. When the distance is beyond a pre-determined level, we assume that there are no spatial effects.

Appendix table 1

Log price per squared-meter - Affected Period 2012 – 2017

	(1) **100yr natural**	(2) **100yr managed**	(3) **50yr natural**	(4) **50yr managed**
Affected	0.255***	0.298***	0.234***	0.166***
	(0.0250)	(0.0263)	(0.0291)	(0.0412)
Post	0.0156	0.0139	0.00774	0.00731
	(0.0242)	(0.0241)	(0.0242)	(0.0242)
Post*Affected	-0.0387	-0.0547	-0.0364	-0.0786
	(0.0325)	(0.0346)	(0.0425)	(0.0587)
Building floor area	0.00156***	0.00154***	0.00159***	0.00165***
	(0.000371)	(0.000370)	(0.000372)	(0.000376)
Site area	0.000916***	0.000924***	0.000908***	0.000906***
	(0.0000791)	(0.0000791)	(0.0000797)	(0.0000797)
Good interior quality	0.0239*	0.0237*	0.0239*	0.0214
	(0.0132)	(0.0132)	(0.0133)	(0.0134)
Poor interior quality	-0.0515*	-0.0501*	-0.0459	-0.0390
	(0.0298)	(0.0298)	(0.0298)	(0.0299)
Good exterior quality	0.0202*	0.0217**	0.0246**	0.0293***
	(0.0109)	(0.0109)	(0.0109)	(0.0110)
Poor exterior quality	-0.0799**	-0.0793**	-0.0816**	-0.0865**
	(0.0384)	(0.0383)	(0.0384)	(0.0386)
Cross lease (2 shares)	-0.111***	-0.110***	-0.112***	-0.109***
	(0.0205)	(0.0205)	(0.0205)	(0.0206)
Cross lease (3+)	-0.236***	-0.240***	-0.239***	-0.225***
	(0.0437)	(0.0435)	(0.0433)	(0.0451)
Slight sea view	0.625***	0.575***	0.753***	0.843***
	(0.101)	(0.102)	(0.0983)	(0.0982)
Moderate sea view	0.877***	0.826***	1.005***	1.156***
	(0.0719)	(0.0732)	(0.0757)	(0.0747)
Wide sea view	1.138***	1.068***	1.228***	1.441***
	(0.0806)	(0.0820)	(0.0834)	(0.0810)
Slight View*Distance	-0.0821***	-0.0747***	-0.100***	-0.114***
	(0.0173)	(0.0175)	(0.0170)	(0.0170)
Moderate View*Distance	-0.0930***	-0.0856***	-0.109***	-0.130***
	(0.0117)	(0.0118)	(0.0122)	(0.0121)
Wide View*Distance	-0.130***	-0.121***	-0.141***	-0.169***
	(0.0137)	(0.0139)	(0.0142)	(0.0140)
Constant	10.51***	10.51***	10.52***	10.51***
	(0.520)	(0.519)	(0.520)	(0.522)
Observations	7975	7975	7975	7975
Adjusted R-squared	0.473	0.474	0.470	0.466

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Appendix table 2

Log gross sale price - Affected Period 2012 - 2014

	(1) **100yr natural**	(2) **100yr managed**	(3) **50yr natural**	(4) **50yr managed**
Affected	0.118***	0.135***	0.129***	0.103***
	(0.0132)	(0.0142)	(0.0166)	(0.0268)
Post	0.0156	0.0157	0.0158	0.0209
	(0.0143)	(0.0143)	(0.0143)	(0.0145)
Post*Affected	0.00731	-0.00293	0.0211	-0.0957
	(0.0233)	(0.0255)	(0.0358)	(0.0676)
Building floor area	0.00395***	0.00394***	0.00395***	0.00398***
	(0.000170)	(0.000170)	(0.000171)	(0.000173)
Site area	0.000206***	0.000209***	0.000200***	0.000202***
	(0.0000346)	(0.0000346)	(0.0000346)	(0.0000348)
Good interior quality	0.0317***	0.0317***	0.0318***	0.0308***
	(0.00614)	(0.00613)	(0.00612)	(0.00612)
Poor interior quality	-0.0350***	-0.0341***	-0.0336***	-0.0303***
	(0.0113)	(0.0113)	(0.0113)	(0.0114)
Good exterior quality	0.0456***	0.0465***	0.0474***	0.0498***
	(0.00544)	(0.00543)	(0.00544)	(0.00543)
Poor exterior quality	-0.132***	-0.132***	-0.132***	-0.136***
	(0.0219)	(0.0219)	(0.0219)	(0.0220)
Cross lease (2 shares)	-0.0564***	-0.0559***	-0.0575***	-0.0555***
	(0.00839)	(0.00839)	(0.00840)	(0.00846)
Cross lease (3+)	-0.114***	-0.116***	-0.117***	-0.110***
	(0.0167)	(0.0167)	(0.0166)	(0.0170)
Slight sea view	0.388***	0.367***	0.435***	0.491***
	(0.0488)	(0.0491)	(0.0470)	(0.0483)
Moderate sea view	0.623***	0.602***	0.661***	0.755***
	(0.0486)	(0.0487)	(0.0489)	(0.0519)
Wide sea view	0.636***	0.608***	0.646***	0.771***
	(0.0496)	(0.0501)	(0.0493)	(0.0502)
Slight View*Distance	-0.0542***	-0.0511***	-0.0609***	-0.0691***
	(0.00775)	(0.00778)	(0.00754)	(0.00772)
Moderate View*Distance	-0.0817***	-0.0786***	-0.0862***	-0.0991***
	(0.00811)	(0.00812)	(0.00816)	(0.00854)
Wide View*Distance	-0.0782***	-0.0742***	-0.0786***	-0.0954***
	(0.00726)	(0.00732)	(0.00728)	(0.00748)
Constant	12.21***	12.21***	12.21***	12.20***
	(0.147)	(0.146)	(0.146)	(0.149)
Observations	8436	8436	8436	8436
Adjusted R-squared	0.774	0.774	0.773	0.771

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses

Appendix table 3

Log land price - Affected Period 2012 – 2017

	(1) **100yr natural**	(2) **100yr managed**	(3) **50yr natural**	(4) **50yr manged**
Affected	0.109***	0.122***	0.130***	0.152***
	(0.0189)	(0.0206)	(0.0240)	(0.0389)
Post	0.0138	0.0133	0.0122	0.0139
	(0.0200)	(0.0200)	(0.0200)	(0.0200)
Post*Affected	0.0207	0.00796	0.0187	-0.0674
	(0.0243)	(0.0259)	(0.0316)	(0.0514)
Building floor area	0.00833***	0.00833***	0.00833***	0.00830***
	(0.000232)	(0.000231)	(0.000231)	(0.000232)
Site area	0.000215***	0.000217***	0.000209***	0.000211***
	(0.0000455)	(0.0000454)	(0.0000451)	(0.0000450)
Good interior quality	0.0291***	0.0290***	0.0292***	0.0282***
	(0.00719)	(0.00718)	(0.00718)	(0.00720)
Poor interior quality	0.0251	0.0262	0.0264	0.0294*
	(0.0174)	(0.0174)	(0.0174)	(0.0174)
Good exterior quality	0.0487***	0.0497***	0.0503***	0.0531***
	(0.00729)	(0.00728)	(0.00728)	(0.00727)
Poor exterior quality	-0.151***	-0.151***	-0.151***	-0.153***
	(0.0324)	(0.0324)	(0.0322)	(0.0321)
Cross lease (2 shares)	-0.0168*	-0.0162*	-0.0179*	-0.0174*
	(0.00944)	(0.00941)	(0.00941)	(0.00942)
Cross lease (3+)	-0.0876***	-0.0890***	-0.0914***	-0.0853***
	(0.0166)	(0.0166)	(0.0165)	(0.0169)
Slight sea view	0.380***	0.366***	0.419***	0.450***
	(0.0656)	(0.0656)	(0.0638)	(0.0630)
Moderate sea view	0.627***	0.614***	0.656***	0.730***
	(0.0557)	(0.0561)	(0.0569)	(0.0583)
Wide sea view	0.794***	0.775***	0.792***	0.887***
	(0.0588)	(0.0598)	(0.0590)	(0.0592)
Slight View*Distance	-0.0514***	-0.0493***	-0.0568***	-0.0613***
	(0.00983)	(0.00983)	(0.00960)	(0.00950)
Moderate View*Distance	-0.0799***	-0.0780***	-0.0832***	-0.0933***
	(0.00860)	(0.00865)	(0.00877)	(0.00901)
Wide View*Distance	-0.102***	-0.0997***	-0.101***	-0.114***
	(0.00929)	(0.00940)	(0.00937)	(0.00944)
Constant	8.722***	8.719***	8.726***	8.717***
	(0.145)	(0.144)	(0.143)	(0.146)
Observations	8436	8436	8436	8436
Adjusted R-squared	0.596	0.596	0.595	0.593

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parentheses.

Appendix table 4

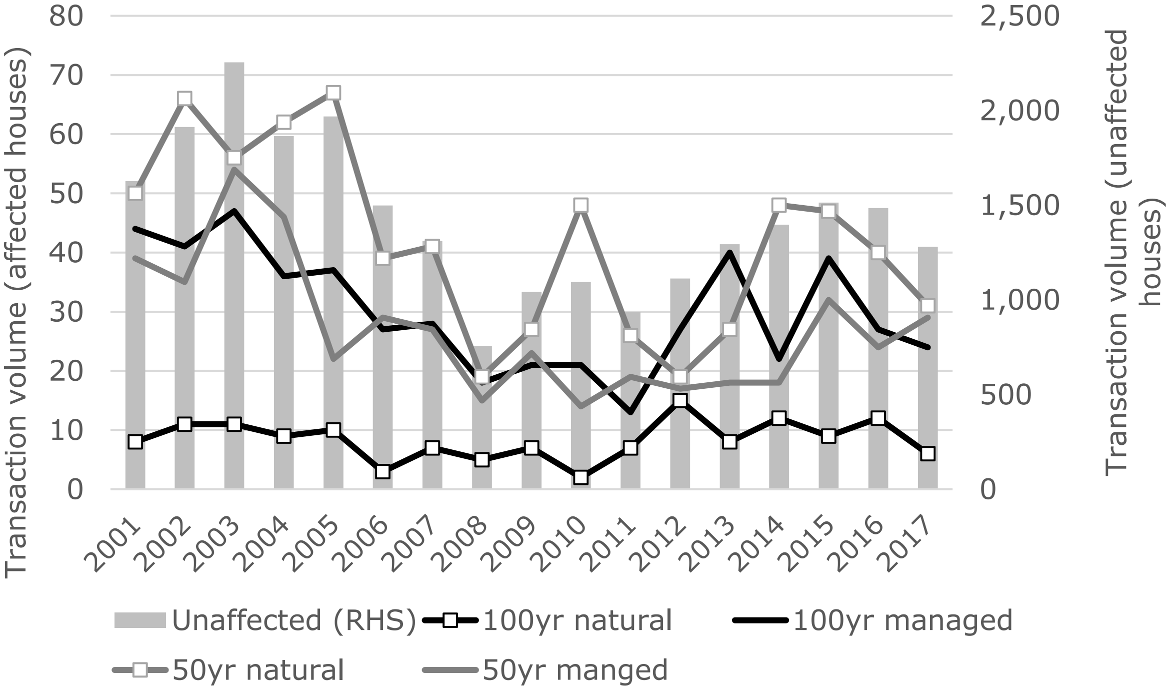
Spatial Regressions - Log gross sale price - Affected Period 2012 - 2017

	SAR				SEM				SAC			
	100yr natural	**100yr manage d**	**50yr natural**	**50yr manage d**	**100yr natural**	**100yr manage d**	**50yr natural**	**50yr manage d**	**100yr natural**	**100yr managed**	**50yr natural**	**50yr managed**
Direct	-0.0021	-0.0179	-0.0123	-0.0511	0.0089	-0.0039	-0.0030	-0.0039	0.0066	-0.0068	-0.0143	-0.0428
	(0.0156)	(0.0164)	(.0203)	(0.0339)	(0.0152)	(0.0160)	(0.0160)	(0.0160)	(0.0153)	(0.0161)	(.0198)	(0.0336)
Indirect	-0.0005	-0.0044	-0.0031	-0.0134					0.0005	-0.0005	-0.0013	-0.0045
	(0.0039)	(0.0041)	(0.0051)	(0.0089)					(0.0013)	(0.0013)	(.0018)	(0.0036)
Total impact	-0.0026	-0.0223	-0.0155	-0.0646	0.0089	-0.0039	-0.0039	-0.0039	0.0071	-0.0074	-0.0156	-0.0473
	(0.0195)	(0.0205)	(.0255)	(0.0429)	(0.0152)	(0.0160)	(0.0160)	(0.0160)	(0 .0166)	(0.0174)	(.0216)	(0.0371)
Spatial												
ρ	0.206***	0.205***	0.209***	0.215***					0.0821***	0.0787***	0.0850***	0.0968***
	(0.0101)	(0.0101)	(0.0101)	(0.0101)					(0.0161)	(0.0162)	(0.0161)	(0.0159)
λ					0.349***	0.348***	0.354***	0.357***	0.274***	0.277***	0.276***	0.268***
					(0.0142)	(0.0142)	(0.0142)	(0.0143)	(0.0212)	(0.0211)	(0.0213)	(0.0214)

***/**/* Indicating the significance levels of respectively 1%, 5% and 10%. Robust standard errors are shown in parenthesis.

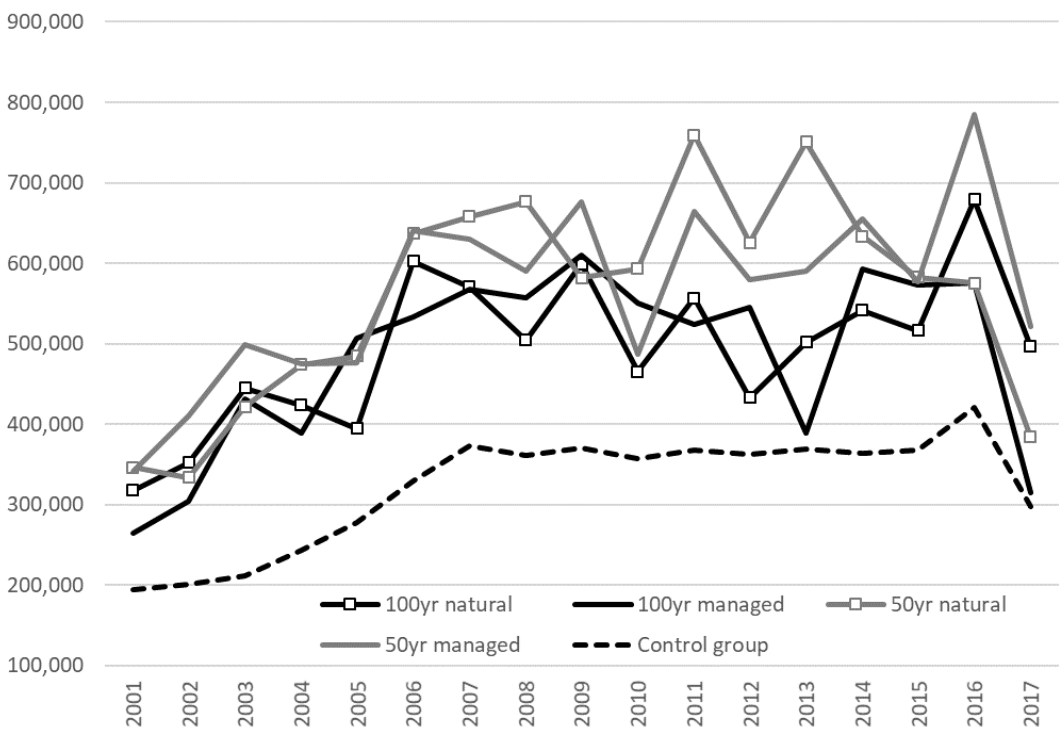
Appendix figure 1

Property transactions in Kapiti Coast



Appendix figure 2

Mean Gross Sale Price Over Time (NZ$)



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