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ABSTRACT *Sea level rise is a consequence of climate change. Using evidence from a coastal community, we pose a question: Do people factor in warnings by scientists and governments about sea level rise when making their investment decisions? Using a difference-in-differences framework, we examine if disclosure of future risks affects coastal property prices. New Zealand's Kapiti Coast published detailed projections of coastal erosion in 2012 and was forced to remove them by the courts in 2014. Results indicate posting of this information had an insignificant impact on prices, suggesting people do not factor in long-term risks of sea level rise, as future risks are not capitalized in prices.* (JEL Q54, R38)

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 (SLR). "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 SLR was also summarized by the Intergovernmental Panel on Climate Change (IPCC):

> 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 SLR 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 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 in zones deemed to be at risk of erosion because of future SLR, and this hazard risk

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information was placed on land information memorandums[1] (LIMs) held by the council. These LIMs are made available to every property buyer, and it is standard practice that LIMs are examined by buyers 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 disclosures 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 relevant not 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 New Zealand 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 neighborhoods, these questions have an impact on the home values of many New Zealanders, and of course, in many other countries.

[1] A LIM is the most comprehensive property report available from a local council and can be requested by any member of the public anytime. The LIM provides a summary of property information held by different departments at the council, including consented work (e.g., original construction and alterations to property), flood risk, and zoning rules, followed by the main part with in-depth information. Almost always, the LIM is reviewed by buyers and the conveyancing lawyer representing them for the transaction (in New Zealand both sides are represented by lawyers, and most lawyers will insist on viewing the LIM). The agreement for sale and purchase contains a standard "LIM condition," which allows a buyer to make the purchase conditional on viewing a satisfactory LIM report.

2. Literature on Coastal Risks and Coastal Properties

Quantifying the Damage from SLR

Not surprisingly, SLR has drawn the attention of researchers globally. With advances in methodologies and geospatial data, strategies for country-level and global-scale estimation of the impact of SLR on existing assets have emerged (Sugiyama, Nicholls, and Vafeidis 2008; Tol 2007; Tol, Klein, and Nicholls 2008). Although useful for framing a national approach to climate policy, such studies lack generalizability for estimating the costs of SLR at the local and the micro scales due to variations in geomorphology as well as socio-economics and politics. For example, residents living in more deprived coastal areas are more likely to believe in climate change and support government regulation than those in more affluent locations (Milfont et al. 2014), maybe because lower-income communities feel more vulnerable to disruptions from natural hazards (Felsenstine and Lichter 2014). Similarly, worldwide public perceptions and awareness of climate change are not evenly distributed, signaling the importance of national, cultural, and geographic factors in shaping perceptions at the individual level (Lee et al. 2015).

The emergence of microeconomic research on the impacts of SLR has been rather slow, with studies originating primarily from North America. For example, Yohe, Neumann, and Ameden (1995) estimate the potential loss of land and built structures with aggregate property data for South Carolina. Following the method developed by Yohe, Neumann, and Ameden (1995), but using disaggregated property transaction data, Parsons and Powell (2001) estimate the cost of beach retreat in Delaware to the year 2050 to be around $291 million (in dollars valued in 2000). Michael (2007) considers the impact of increased storm surge flooding in Chesapeake Bay communities and finds that damage from storm floods may be 28 times greater under a two-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 could reach $7 billion (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.

Hidano, Hoshino, and Sugiura (2015) use regression discontinuity design and seismic risk maps to similarly identify the price impact of seismic disaster 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 method similar to that of Hidano, Hoshino, and Sugiura (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 fail because of heterogeneity in assessments by buyers of the relevant risks. Different agents could have, for example, different views about temporal discounting or may have a different awareness of the erosion risk (or of climate change). In a recent study, Bernstein, Gustafson, and Lewis (2019) estimate a 7% discount in home prices exposed to SLR (if sea levels were to rise by 6 feet—significantly more than the median prediction for this century). They find further evidence of deeper discounts among more “sophisticated” buyers and sellers (investors rather than owner-occupiers). Similarly, Baldauf, Garlappi, and Yannelis (2018) observe that differences in beliefs about SLR (climate change believers vs. deniers) are reflected in house prices, with properties in “believer” neighborhoods selling at a discount compared to “denier” neighborhoods.

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 predisaster level after two to three years at most (e.g., Atreya, Ferreira, and Kriesel 2013). Sometimes, the effect of catastrophic events is even measured only in months (Deng, Gan, and Hernandez 2015). Researchers have examined both the impact on prices in the same location in which the catastrophic event has occurred, but for undamaged properties (Deng, Gan, and Hernandez 2015; Gibson, Mullins, and Hill 2019), 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, Grimes, and Fabling 2018a, 2018b).

In an efficient market with homeowners well informed of risks, fully insured properties should trade at a discount equal to the capitalized 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, finds 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). Pope (2008) observes that mandatory disclosures of flood risk reduced house prices by approximately 4%.

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 first study to focus on this question.

Challenges in Indentifying 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 (Beltrán, Maddison, and Elliott 2018). Therefore, including only a single variable controlling for location either inside or outside of a risk zone may underestimate the value of the risk if positive and negative water-related externalities are specified separately (Daniel, Florax, and Rietveld 2009a, 2009b) A few studies account for such competing effects and therefore provide an 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) isolates the 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 (see, e.g., Bakkensen and Barrage 2017; Baldauf, Garlappi, and Yannelis 2018; Bernstein, Gustafson, and Lewis 2019). Factors such as sea views and recreational access potentially mask or override property value reductions (Daniel, Florax, and Rietveld 2009a). Furthermore, rising property markets and expectations of future capital gains can potentially desensitize prospective buyers to SLR risks (DEFRA 2009).

Yet, empirical evidence to determine if official information about future coastal hazard risk is reflected in house prices is only now beginning to emerge. 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 home buyers and sellers. This is an important policy question.

Two published studies, by Baldauf, Garlappi, and Yannelis (2018) and Bernstein, Gustafson, and Lewis (2019), have investigated house price effects associated with public information on SLR risk. Our study follows in this vein but considers erosion (loss of land), whereas these earlier studies focus on coastal inundation. The critical point of difference, however, is that our study considers public information that is genuinely accessed and utilized by home buyers and sellers.

Both Baldauf, Garlappi, and Yannelis (2018) and Bernstein, Gustafson, and Lewis (2019) attempt to measure the price effect of publicly available digital maps published by the National Oceanic and Atmospheric Administration, which launched their online "Sea Level Viewer" tool[2] in 2011 to visualize coastal inundation risks. Critically, the creators of this online viewer clearly stipulate that it is a "screening-level tool" and "the data and maps in this tool illustrate the scale of potential [coastal] flooding, not the exact location" (Marcy et al. 2011, 477). Not only

[2] See https://coast.noaa.gov/slr/.

is the online mapping tool not designed to precisely pinpoint SLR risks at the individual parcel level, due to the lack of parcel boundaries and inability to zoom close in, it is difficult, if not impossible, for a novice user to determine whether a particular property is at risk of coastal inundation. As noted by Pope (2008, 552), when studying flooding risks if "buyers [and sellers] are uninformed, then the standard estimated implicit price will suffer from attenuation bias relative to a 'full information' estimate of the disamenity."

In contrast to the studies by Baldauf, Garlappi, and Yannelis (2018) and Bernstein, Gustafson, and Lewis (2019), the buyers and sellers transacting in the Kapiti Coast within our study were fully aware of the SLR risks associated with the property being traded because the relevant information was prominently displayed on the property's LIM. Whereas the previous studies have likely suffered from severe attenuation bias, our study does not suffer the same bias, given vetting a property's LIM during due diligence is standard practice in New Zealand (and typically monitored by the lawyers executing the transaction). While these two studies, in particular, estimate answers to different questions than the one we pose, it is nevertheless intriguing that they find a more significant decline in prices in spite of their attenuation bias.[3]

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 (Glass and Pilkey 2013).

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).[4] 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-differences (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 values are influenced by similar contemporaneous factors. In addition, we are able 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 follows:

[3] Given Baldauf, Garlappi, and Yannelis's (2018) focus on belief in climate change, the more directly comparable is Bernstein, Gustafson, and Lewis's (2019) study. They find a 7% decline in prices for properties within 6 feet of SLR (with an average of 4.43 feet). This is a significantly higher threshold than the consensus predictions for SLR by the end of the century, so this result is doubly surprising. Two differences with our estimations are noteworthy: (1) we look for the impact of new information about SLR risk, rather than SLR risk per se; (2) we control for significantly more amenities (especially sea view), so our hedonic model is likely more precisely estimated.

[4] Since 2000 and leading up to the global financial crisis, the New Zealand property market experienced a surge in demand for housing, during which 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.

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

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 ($Affect_i = 0$) comprises 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 DID 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).[5] 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 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. In alternative spatial specifications (see Appendix for the exact specifications), we estimate the hedonic model assuming several variants of the standard spatial model.

4. Study Area and Data

Kapiti Coast Study Area

The Kapiti Coast is a coastal area in the southwest corner of the North Island of New Zealand (Figure 1[6]). In 2012, the Kapiti Coast District Council (KCDC) was preparing for a new district plan. The main focus for the 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 SLR and other future potential effects of climate change. Policy 24 in the New Zealand Coastal Policy Statement of 2010 (New Zealand Government 2010, 23) 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, 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.[7]

The coastal erosion projections were based on detailed analysis of current and historic data (KCDC 2012). The collected data included past coastal hazard studies in the region, historical aerial photographs (1940s to present), cadastral surveys (1890s to present), and projections of future climate change and SLR from the Ministry for the Environment guidelines (2008).

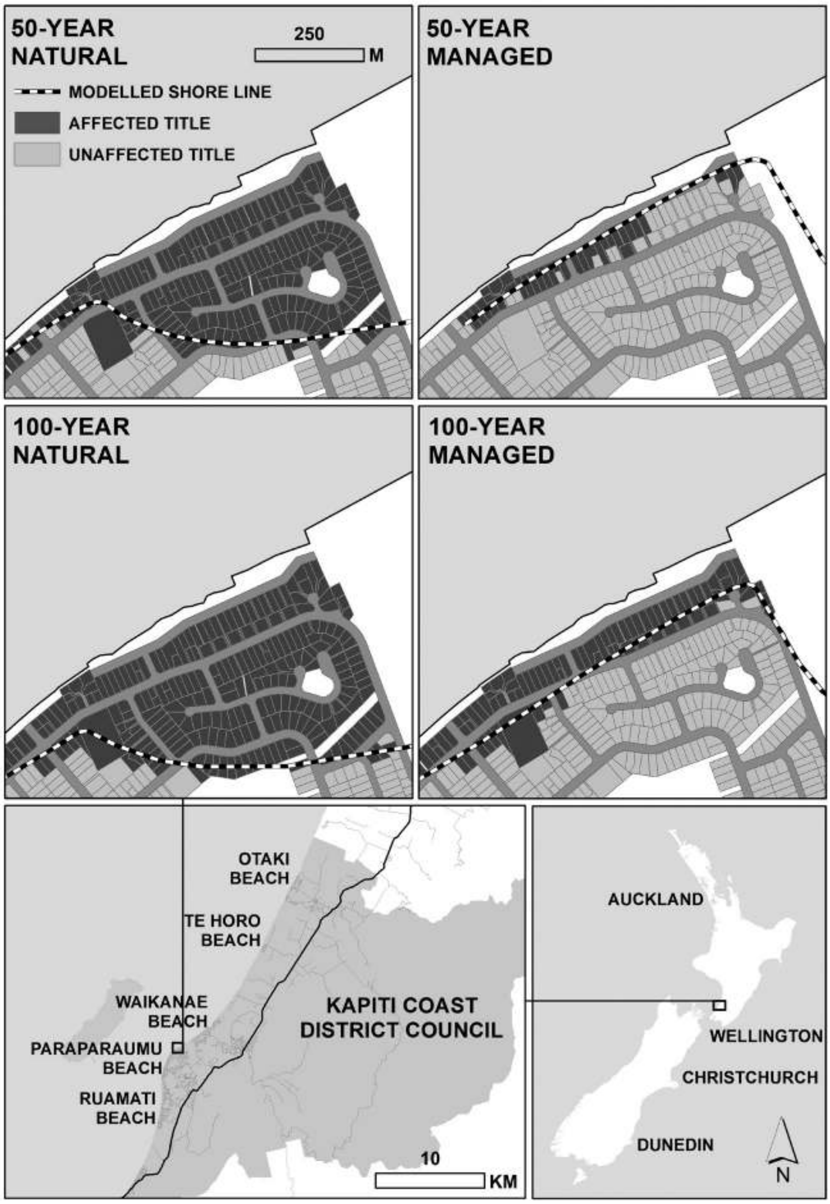
The hazard risk information was then put on affected properties' LIMs, and notification letters were sent to affected property owners on August 25, 2012, as required by the Local Government Official Information and

[5] Because the Kapiti Coast area has not experienced any large/moderate storm-surge/erosion events 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 hydrometeorological hazards in the last 30 years in the Kapiti Coast district (Fleming et al. 2018).

[6] There are four classifications, corresponding with the four coastal hazard risk lines, with an example from Waikanae. The number of treated observations in each specification are 577 (50 year natural), 521 (50 year managed), 347 (100 year managed), and 130 (100 year natural) out of 8,436 sale transactions between 2009 and 2017.

[7] Current risks are storm erosion and catch-up erosion (if currently existing seawalls are not maintained, as in the unmanaged scenarios). Future risks are the effect of projected sea level rise and continuation of existing erosion trends.

Figure 1
Study Area Location and Coastal Erosion Scenarios



Meeting Act.[8] The coastal LIMs contained neighborhood maps of shoreline projections to inform people about the hazard risk in their neighborhood. 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).

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

The public disclosure of hazard information led to an immediate public and media outcry. A high-profile interest group—Coastal Ratepayers United—was formed to prevent the dissemination of this report of coastal hazard lines and challenge the assessments, with public pressure applied to elected district council members. In 2013, coastal residents requested a High Court judicial review and sought to exclude the coastal hazard information from LIMs. In December 2013, Judge Joe Williams ruled that under Section 44A(2)(a) of the Local Government Official Information and Meetings Act 1987, the "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."

Due to the pressure from Coastal Ratepayers United, 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,[9] whereas the 50- and 100-year managed line maps assume the management/maintenance of current public seawalls/inlets and other protection works.

Property Transactions and Other Data

This study analyzes sales transactions of freestanding houses (excluding flats and apartments) sourced from CoreLogic[10] for the Kapiti Coast District Council from the first quarter of 2009 through the first quarter of 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 m^2 or over 500 m^2, lot size was over 2,000 m^2, or the entry had any missing data. Also transactions were deleted if flagged as outliers (standardized residuals beyond three standard deviations), had leasehold rather than freehold interests, or were explicitly coded as not reflecting an arm's-length transaction (nonmarket sales price, related party sale, 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 indication of whether the property's street number is 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 includes numerous spatial and attribute databases that comprise the country's cadastral (land title and property ownership) and topographic information.[11]

The first objective is to identify title transfers in the Kapiti Coast District that have occurred within the study time frame (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

[9] According to the New Zealand 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 the Kapiti Coast district.

[10] See https://www.corelogic.com.

[11] Data held by Landonline can be freely accessed at https://data.linz.govt.nz/. 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."

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 quarter 1 of 2009 through quarter 4 2018 are analyzed to take into account the duration between sale and transfer.

With transferred titles identified, the next step is to remove from the dataset nonmarket, 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 nonrelated party, or market, title transfers are then associated with their respective land titles using Landonline's "title instrument" dataset.

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 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 time frame.

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 time frame.

When matching CoreLogic sales data with Landonline title transfer records, approximately 250, or 3% of all sales analyzed, aligned to two or three potential title transfers. Sales transaction histories, including date of sale and gross sale price, are publicly available for most properties on a number of websites.[12] Using these online resources we manually investigated each instance and precisely matched these sales to their respective land titles.[13]

The district's land title polygons were overlaid with drawing exchange format (DXF) line themes representing each of the four modeled "future shorelines."[14] Figure 1 provides an illustration of how these line themes are used to code land titles as being affected or not.

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 A1. 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)

[12] For example, homes.co.nz and qv.co.nz.

[13] Related parties were identified by comparing text strings comprising the sellers and purchasers involved in a given title transfer. The seller string was truncated to 10 characters in length to avoid capturing any punctuation (namely, commas) or notations (e.g., 1/2 share). This tended to capture the foremost mentioned owner's first name and a portion of his or her middle or last name. The truncated seller string was then used to search the purchaser text string. When a match was found the transfer was recorded as a related-party sale. A manual review of this process did not identify any erroneous coding. An unknown proportion of sales transactions that were not arm's length were filtered out by CoreLogic prior to supplying the data. In terms of Landonline title transfers, just over 8% were flagged as involving related parties. The bulk of these represent the transfer of ownership into a family trust. Other patterns found included the restructuring of relationship property in the wake of a breakup/divorce. Most common was the conversion of simple joint ownership to explicit half shares. When matching CoreLogic sales data with Landonline title transfer records, approximately 250, or 3% of all sales analyzed, aligned to two or three potential title transfers. Thankfully, sales transaction histories, which include date of sale and gross sale price, are publicly available for most properties on a number of websites including homes.co.nz and qv.co.nz. Using these online resources we manually investigated each instance and precisely matched these sales to their respective land titles.

[14] These DXF files were provided by Dr. Roger Shand for use in this study.

sale price (Appendix Figure A2) for all the subsamples: properties in the 50-year-managed, 50-year-unmanaged, 100-year-managed, 100-year-unmanaged, and control group (properties farther 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 of whether to sell appears unrelated to the placement of erosion risks on LIMs in September 2012 or to their removal in October 2014.

To ensure that property owners did not mitigate against SLR risk (e.g., with a private sea wall[15]) in advance of the sale, we examined official records of building alterations/modifications lodged with the local administration for properties that were transacted during the study period. Between 1995 and 2017 there was a total of 343 building consents issued. The descriptions of all issued consents were analyzed, and none involved construction work that would mitigate against SLR risks.

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% to 45% lower price compared to properties in treated groups (B and D).[16] 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 and 792 m^2.

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

5. Results

Table 2 presents the results of the DID estimation for the four coastal hazard scenarios. In addition, Table 3 reports results of three spatial regression models including spatial autoregressive (SAR), spatial error (SEM) and spatial autocorrelation (SAC) models.[17] The models achieve a reasonable fit, with adjusted R^2 of 0.774. 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 farther away from the coast does not command as much benefit from the same appreciable water view.[18]

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

[15] An example covered by the media: https://www.stuff.co.nz/auckland/107869408/beachfront-homes-seawall-obstacle-to-walking-on-beach-aucklanders-say.

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

[17] For a detailed description please refer to Appendix Section B.

[18] The measure of elevation is controlled in all regression specifications; it proxies for flood risk (which is distinct from erosion risk). Its coefficient is always very small, negative, and statistically significant. Removing this control variable from the regression does not change our result of treatment effect. Reliable flood maps are not available for the Kapiti coast. Flooding in this region is associated with the rivers flowing down from the nearby mountains and is not at all associated with the coastal properties we focus on here.

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 (std. dev.)	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 (m^2)					
Mean (std. dev.)	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 (m^2)					
Mean (std. dev.)	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%)

warnings on affected properties' LIMs in September 2012. As such, the main coefficient of interest is the DID coefficient *Post* × *Affected*, presented in 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 SLR would cause the affected properties to be discounted. In Appendix Table A7, we examine the power of our hypotheses tests. Given the significant size of our samples, and even though the treatment groups are not very large, our tests appear to have enough power to identify any

Table 2
Left-Hand-Side Variable Is Log Gross Sale Price (Affected Period: 2012–2017)

	(1) 100 Years Natural	(2) 100 Years Managed	(3) 50 Years Natural	(4) 50 Years Managed
Affected	0.121***	0.140***	0.156***	0.234***
	(0.0139)	(0.0149)	(0.0183)	(0.0300)
Postdisclosure	–0.0139	–0.0138	–0.0186	–0.0200
	(0.0157)	(0.0158)	(0.0159)	(0.0155)
Post × Affected	–0.0018	–0.0136	–0.0064	–0.0587
	(0.0206)	(0.0223)	(0.0295)	(0.0496)
Floor area	0.0039***	0.0039***	0.0039***	0.0039***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Site area	0.0002***	0.0002***	0.0002***	0.0002***
	(0.00003)	(0.00003)	(0.00003)	(0.00003)
Good interior	0.0317***	0.0316***	0.0326***	0.0317***
	(0.0061)	(0.0061)	(0.00608)	(0.0060)
Poor interior	–0.0352***	–0.0337***	–0.0332***	–0.0298**
	(0.0113)	(0.0114)	(0.0115)	(0.0118)
Good exterior	0.0459***	0.0463***	0.0452***	0.0489***
	(0.0054)	(0.0054)	(0.0055)	(0.0055)
Poor exterior	–0.133***	–0.133***	–0.135***	–0.136***
	(0.0219)	(0.0221)	(0.0229)	(0.0230)
Cross lease (2 shares)	–0.0563***	–0.0562***	–0.0577***	–0.0597***
	(0.0083)	(0.0084)	(0.0085)	(0.0086)
Cross lease (3+)	–0.114***	–0.116***	–0.116***	–0.123***
	(0.0167)	(0.0167)	(0.0169)	(0.0180)
Slight sea view	0.387***	0.367***	0.409***	0.335***
	(0.0487)	(0.0489)	(0.0530)	(0.0553)
Moderate sea view	0.623***	0.607***	0.618***	0.468***
	(0.0487)	(0.0492)	(0.0516)	(0.0551)
Wide sea view	0.637***	0.611***	0.587***	0.330***
	(0.0496)	(0.0506)	(0.0562)	(0.0748)
Slight view × Distance	–0.0542***	–0.0513***	–0.0570***	–0.0456***
	(0.0077)	(0.0077)	(0.0082)	(0.0085)
Moderate view × Distance	–0.0817***	–0.0795***	–0.0804***	–0.0573***
	(0.00812)	(0.00818)	(0.00845)	(0.00885)
Wide view × Distance	–0.0784***	–0.0749***	–0.0709***	–0.0358***
	(0.0072)	(0.0073)	(0.0079)	(0.0101)
Constant	12.22***	12.21***	12.22***	12.25***
	(0.145)	(0.144)	(0.0481)	(0.0488)
Observations	8,436	8,380	8,206	7,989
Adjusted R^2	0.774	0.774	0.774	0.774

Note: Robust standard errors are shown in parentheses.
, * Significance at the 5% and 1% levels, respectively.

association, if there is one in the data; in other words, our identification scheme is not underpowered.

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 5.87% (column 4 in Table 2).[19] These properties would be "the first to go" even if the erosion risk is managed by the local council, and therefore they also have the highest current risk of exposure to coastal inundation and storm surges. We consider 5.87% to be a small effect; it appears that buyers of houses closer to the waterfront are more aware of the coastal hazard risks, but the effect is still small although imprecisely identified.

This assessment of our results, however, depends on several other assumptions. Most obvious is the importance of the assumed dis-

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

count rate. If we were to adopt the discount rate used in the most recent version of Nordhaus's DICE integrated assessment model (2.5%), we would expect a significantly larger effect on prices than what we found (Nordhaus 2017). If the discount rate is even lower, as was advocated for in the very influential Stern Report (Stern and Taylor 2007), then the effect should have been even larger. Our results are more aligned with an assumed rational full-information marketplace if the discount rate is closer to 5%, or if the homeowners expect the government to fully compensate them for their property's value before the land is actually eroded (and before market prices reduce its price significantly).

Having found no significant risk in the benchmark ordinary least squares regressions, we also estimated spatial regression models to control for the spatial dependencies in the pricing of properties (i.e., property prices are affected through several spatial channels by prices of properties in the immediate neighborhood; see Appendix Section B for details of the specifications). Table 3 provides these results. Supporting the above findings, we find that the effect of the hazard information is small and insignificant across the different models, specifications, and treated groups.[20] We do find that the estimated spatial autoregressive (ρ) and autocorrelation (λ) coefficients are statistically significant; and the sale price of a property is positively influenced by neighboring properties' sale prices, suggesting that this model might be the appropriate one for our analysis.

In addition to this benchmark specification, we estimate three alternative specifications (see Appendix Tables A1–A3). In the first specification, we use the sale price per square meter as the 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

[20]The circular neighborhood of fixed radius (approximately 340 m, optimized by the geographical analysis software) and five nearest-neighbor techniques were applied to construct the inverse distance-weighted matrices. With both weighting matrices, the results of spatial regression are very similar. Table 3 reports results using the fixed-radius weight scheme.

Table 3

Spatial Specifications: Left-Hand-Side Variable Is Log Gross Sale Price (Affected Period: 2012–2014)

	SAR				SEM				SAC			
	100 Years Natural	100 Years Managed	50 Years Natural	50 Years Managed	100 Years Natural	100 Years Managed	50 Years Natural	50 Years Managed	100 Years Natural	100 Years Managed	50 Years Natural	50 Years Managed
Direct	−0.0021	−0.0174	−0.0113	−0.0481	0.0089	−0.0036	−0.0025	−0.00226	0.0066	−0.0067	−0.0140	−0.0325
	(0.0156)	(0.0163)	(0.0210)	(0.0234)	(0.0152)	(0.0149)	(0.0149)	(0.0149)	(0.0153)	(0.0153)	(0.0193)	(0.0325)
Indirect	−0.0005	−0.0041	−0.0029	−0.0126					0.0005	−0.0005	−0.0011	−0.0033
	(0.0039)	(0.0031)	(0.0051)	(0.0089)					(0.0013)	(0.0013)	(0.0018)	(0.0033)
Total impact	−0.0026	−0.0212	−0.0148	−0.0446	0.0089	−0.0035	−0.0035	−0.0035	0.0071	−0.0074	−0.0146	−0.0388
	(0.0195)	(0.0201)	(0.0252)	(0.0401)	(0.0152)	(0.0153)	(0.0153)	(0.0153)	(0.0166)	(0.0174)	(0.0215)	(0.0370)
Spatial												
ρ	0.206***	0.203***	0.207***	0.210***					0.0821***	0.0785***	0.0845***	0.0957***
	(0.0097)	(0.0097)	(0.0097)	(0.0097)					(0.0161)	(0.0160)	(0.0161)	(0.0159)
λ					0.349***	0.344***	0.352***	0.356***	0.274***	0.275***	0.274***	0.247***
					(0.0132)	(0.0132)	(0.0132)	(0.0135)	(0.0212)	(0.0211)	(0.0212)	(0.0211)

Note: Robust standard errors are shown in parentheses. SAR, spatial autoregressive model; SEM, spatial error model; SAC, spatial autocorrelation model.
*** Significance at the 1% level.

to October 2014). In the third iteration (Appendix Table A3), we estimate only the price of the 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 Section A for explanation of land value estimation).

Appendix Table A4 has the same specification as in the main result table (Table 2) but with a constant sample size in each column (for each scenario).[21] Moreover, we keep only repeated sale observations and rerun the main specification. The results are shown in Appendix Table A6. There are 3,317 repeated property sales in the sample. In column 5 of the table, only houses that have their first sale before August 2012 were selected. The sample size is further reduced to 1,912.

The results for all alternative specifications, as shown in the Appendix, are very similar to the benchmark regressions results. In none of the alternative specifications are the estimates of the DID effect 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. In addition, the average/median regression residuals over time were plotted, as a robustness test. Appendix Figure A3 was regressed for the whole sample, while in Appendix Figure A4 only preevent observations were included in the regression specification. The median residuals follow a more pronounced preevent parallel trend, compared to the average residuals.

Next, we examine effects of coastal hazard risk on property prices over time by estimating annual regressions for each hazard group.[22] The results are shown in Figure 2. We observe that the coefficients of $Affect_i$ are 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 seems to have had little effect on property pricing.

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 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 six 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 these risks, 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.

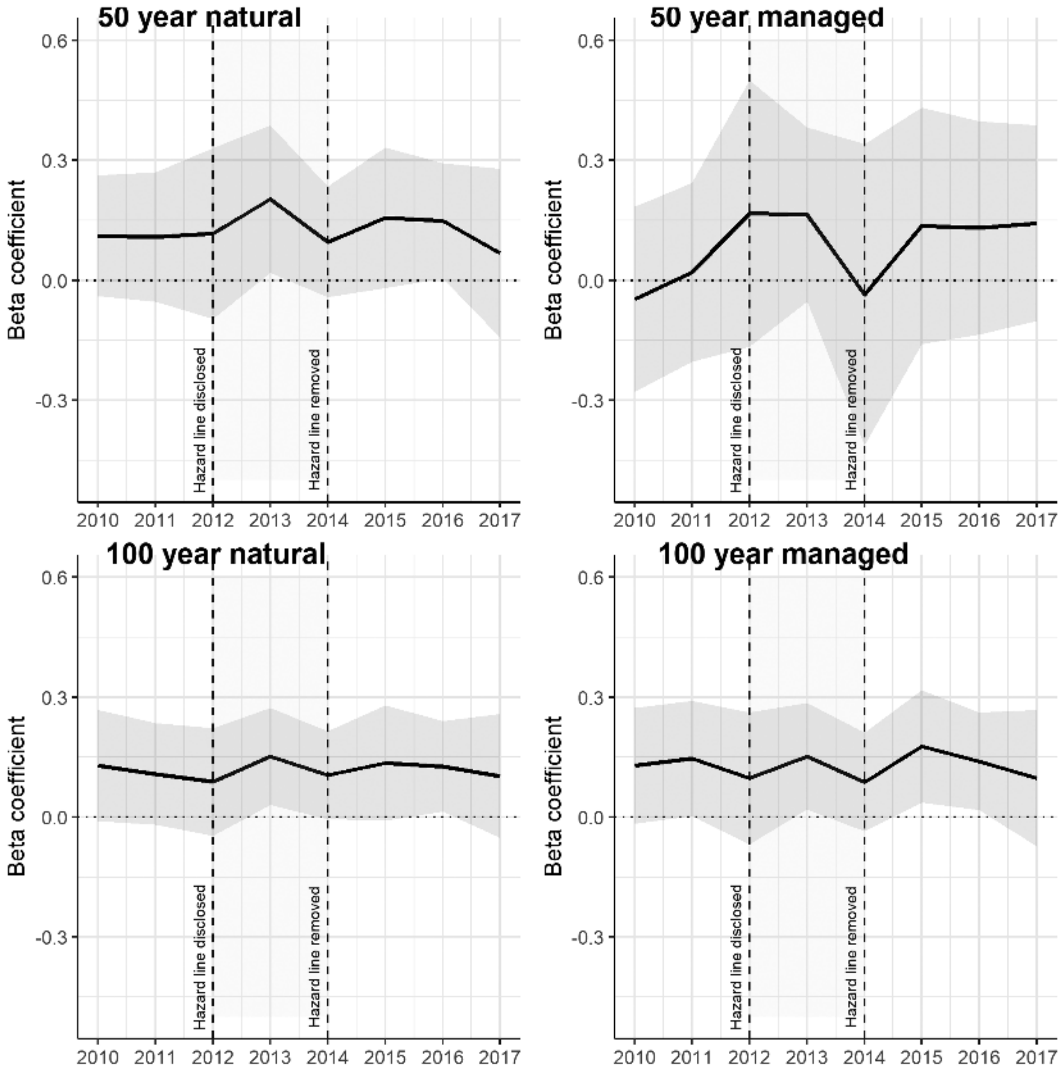
It might be the case, however, that only some people are ignoring these risks, and given the characteristics of real estate markets, the number of people "who care" is not yet enough to be observable in a relatively limited geographical area (see Bakkensen and Barrage

[21] Observations are treated in some specifications, but switch to the control group in other specification.

[22] The $Post_i$ variable and interaction term are excluded in the specifications. Regressions are run for each sample year. Then, the coefficient magnitudes for the affected group (properties that fall within the erosion lines) are gathered and plotted. This is a test to extract insight about the magnitude and significance of the treatment effect over time. We conclude that there is no clear trend of change in the plotted treatment coefficient both pre- and postevent.

Figure 2

Effect of Coastal Hazard Risk on Property Price over Time (Gray Area Indicates 95% Confidence Interval)



2017). More generally in society, there is a growing awareness of climate-related risks. However, until recently, most home buyers did not have access to data showing the direct physical risks at the asset level. Two recent studies (Baldauf, Garlappi, and Yannelis 2018; Bernstein, Gustafson, and Lewis 2019) investigate house price effects associated with the release of the publicly accessible digital maps that display SLR risk. These maps, however, show the potential impact but not the exact location. Whereas the buyers and sellers transacting within our study were fully aware of the SLR risks associated with the property being traded, because the relevant information was prominently displayed on the property's official documents (the LIMs), therefore, reducing attenuation bias relative to a "full information" estimate of the disamenity (Pope 2008).

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. In fact, there is a greater recognition by the government of the limits of the ability of physical structures to protect coastlines against SLR. Some local governments are starting to withdraw funding to defend private property and make plans for managed retreat (Fallon 2019). Availability and affordability of insurance is also beginning to impact homeowners. A potential implications of these changes is the redistribution of risk responsibilities between the government and the individuals, increasing the accountability of those that are at risk (i.e., coastal homeowners, both present and future).

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