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Sea Level Rise and House Price Capitalisation

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Abstract

Economic theory and extant research suggest that flood prone properties should attract a discount. This concept can be extended to properties affected by future sea level rise but there is limited information for purchasers to judge and make informed decisions about their investment. Using a comprehensive dataset comprising statutory rating valuation information and sales transactions for the period 2011 – 2016, a hedonic framework is applied in order to ascertain the implications of the existing flood discount and potential price effects of future sea level rise. The hedonic model identifies a price discount effect for properties affected by known flooded areas, whilst sea level rise has no notable effect on valuations or sales data. The results highlight that purchasers do not appear to price sea level rise risk and are under-prepared for the future challenges and implications sea level rise and the ancillary effects of future flooding, inundation and storm surge.
Keywords: *Sea level rise,house prices,flood risk,hedonic pricing, information asymmetry*[1]

1. Introduction

Many of the worlds' major cities are situated on coastlines and rivers systems which house 40% of global population (in 1990), and by 2050 2.4 billion people will populate these areas, 80% within cities (Kummu et al., 2016). These coastal cities will likely be threatened directly

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or indirectly by sea level rise due to climate change (Neumann et al. 2015). Approximately 10% of the world's population situated in low-elevation coastal zones below 10 metres in elevation (McGranahan et al., 2007) Predictions for sea level rise are uncertain, as many forecasts are based on anticipated projections of reductions in carbon emissions and have varying consideration of factors that may amplify the effects of predicted sea level rise. Yet pessimistically, current approaches to mitigation are not meeting targets and future targets of the world's greatest polluters is at odds with a culture of economic growth, rising middle class consumerism and exponential population growth. As a result, sea level rise is not necessarily an uncertain event, more a known event that is occurring presently, albeit slowly, but will likely increase more rapidly in the future. The more pressing question, is what effect will this have economically, and one of the most exposed areas for consideration is property.

The impact on housing globally will be significant from both total inundation from sea level rise and increased periodic flooding from storm events and storm surges. Sea level rise risk is substantially underestimated in the effects it will have on property, due to modelling expectations focusing on the direct sea level rise, with a general assumption of flat water and little consideration of wave setup, wave heights, tides, storms and storm surges (Liu, 1997: Yohe et al, 1999; West et al. 2001; Nicholls, 2002; Warren-Myers et al. 2018). As an example, Warren-Myers et al. (2018a) found for a bayside municipality in Australia, that at a 0.8 metre sea level rise, only 0.24% of properties would be affected. However, given a conservative storm surge (of 0.5 metres), existing flood levels and high tide consideration this increased to affecting 40% of the municipality. Further, a modelled storm surge for the case study area investigated a storm surge of 1.5 metres, would lead to close to 50% of the properties in the municipality affected (Climate Code Red, 2012; Warren-Myers et al. 2018a). Similar findings by Michael (2007) who determined in an examination of Chesapeake Bay (United States) the damage losses from episodic flooding was going to be nine times the loss from complete inundation at 3-foot sea level rise. Housing plays an important role in economic markets and the contraction or loss of values within markets will have intense implications for individuals, businesses and broader financial markets. As the risks and actual losses from sea level rise become more evident, and markets price the flood risk, future changes will result in those that are least able to afford the risks will be the most exposed, increasing issues of social justice (Pryce and Chen, 2011).

This leads to purchasers' awareness and knowledge of the risks posed to the property, as a purchaser will factor and consider the risks and probability of detrimental exposure of the property to potential future losses or costs in the offering of a price for a property (McDonald, 1987; McClelland, 1990). This assumes rational decision-making and that humans, consider the risks and probability of losses in determining the price they are willing to pay. Disaster risks' influence on property values is highly dependent on the information provided to the purchaser, their awareness and subsequent due diligence. Consequently, decision-making for housing choice is dependent on a cluster of factors that drive decisions, in regard to disclosed disaster risk information; event frequency, impact and history; and decision-making factors status quo bias, herd mentality and heuristics including anchoring, availability, and representative heuristics.

Sea level rise risk research has focused on modelled loss of property and values or costs as a result of inundation commonly based on LiDAR or height elevation studies (Titus, 1991; Darwin et al., 2001 Bin et al. 2011; Scott et al., 2012; Fu et al. 2016; Warren-Myers et al. 2018). Further, extension of this work has also considered the implications of increased flooding in sea level rise scenarios (Michael, 2007; Pryce and Chen, 2011; Warren-Myers et al., 2018). Whilst other research has focused on the house price implications as a result of sea level rise protection measures or risk reduction (Hamilton, 2007) and forward anticipation of investors' and developers' decision-making to effectively seek higher ground (Bunten and Kahn, 2017). More recently, Ortega and Taspinar (2018) demonstrated the increasing discounting associated with properties in flood prone areas and the effect major events like hurricane Sandy has on property values. Unlike the flood literature, the sea level rise scenario modelling research estimates a 'what if' scenario, lacks actual events, and is highly implicated by uncertainty and information asymmetry. However, evidence of flooding discounts for flood prone or designated properties and research like Ortega and Taspinar (2018), suggest that there is an underestimation of the price implications and subsequent risk to coastal properties in relation to sea level rise and future flooding implications.

Action in regard to households taking mitigating or adaptive approaches to ownership and investment in relation to sea level rise, is relatively unknown. Where extant decision-making heuristics in relation to sea level rise are not triggered, perhaps because of: the ongoing uncertainty debate of climate change, global warming and sea level rise (anchoring and adjusting and representative heuristics); the lack of information provision of sea level rise risk and limited events in which people are affected (availability heuristic), and a response to maintain the status quo in buying habits (particularly in strong markets) and herd mentality continuing of purchasing land at a premium in or near coastal area.

Flooding studies have focused on these aspects steadily overtime, and a recent meta-analysis by Beltran et al. (2018) specifically focused on flood plain discounts in house prices, where information is provided about the 'risk' (a designated flood plain) and then further analysed in the context of recent 'events'. Consequently, the study demonstrated various heuristics, noted above at play, and its implication in the conclusion of a 4.6% discount across the studies. For example, knowledge of information (the flood plain designation) provides information on which to anchor and adjust to; and the representativeness and availability heuristics indicated by the event analysis and how this then affected values depending on timing of events, frequency of events and time since event. As demonstrated in Beltran's analysis, various aspects of the different heuristics have been tested to examine the implications on decision-making in housing purchases and its relationship to flooding risk.

Botzen et al.'s (2008b) study of flood perception, willingness to pay and engagement in strategies found evidence suggesting that consumer behaviour, perceptions and attitudes play a major role in changes to properties' market value. As does the importance of flood information and disclosure as modelled by Votsis and Perrels (2016) indicating a rational response to flood risk information. This is further supported by Beltran et al.'s (2018) meta-analysis, examining floodplain exposed properties and event based research which provided a thorough analysis of the different approaches to flood modelling and its implications for property prices, being either value add demonstrated through the economic benefits of flood protection either natural or man-made and willingness to pay for protection; and the value discounting where reduction in the estimate of benefits for properties at risk of flood which is then capitalised into prices. Many of these studies highlight the effect of time dependency and frequency of event affects purchasers' decision-making significantly. For example, in that a recent disaster event might trigger a greater response initially but over time the market demonstrates a level of recovery (Eves, 2002; Loomis, 2004), or where repeated events lead to systemic long-term discounting (Eves, 2004a; Mueller, 2009). Suggesting, that reactions are enhanced and pricing becomes more clearly factored in the long-term when events are occurring regularly and of significant effect. When events occur more often particularly when there is media attention, public awareness is heightened and this has longer term impacts on value, conversely infrequency of events decreases awareness (Ortega and Taspinar 2018; Beltran et al. 2018; Eves, 1999, 2001, 2002; Wilkinson and Eves 2014).

The perception of risk for an asset is almost as significant as the actual risk to property market values. In the UK only 50% of residents living in flood prone areas are actually aware of this fact (Eves, 2004), as often purchasers are unaware their property is situated in a flood zone or what the risks and probability of flood losses and costs are (Chivers and Flores, 2002). As an informed purchaser will make decisions based on both actual and perceived risks, which do change over time, as demonstrated Ortega and Taspinar (2018); who found a gradual and persistent negative impact on houses identified in a flood zone. This was a result of existing knowledge of flood zones with the added emphasis coming through a significant and substantial flood event, demonstrating the influence of a significant event on existing information, reinforcing and then creating a long-term effect on property values. This is further supported by Cameron and Shah (2015) psychological experiment that found those exposed to a recent flood event were more risk adverse than those not affected, and there was a greater expectation that they may be affected again. However, limited evidence of discounting, may be a result of expected future losses being underestimated, or not considered, as short term benefits and costs outweigh the long-term possibility of a flood (or sea level rise) and the associated losses and costs that may never occur (Koning et al. 2017).

Two key factors of decision-making and price effects emerge from the literature. Firstly information and secondly event experience. In relation to sea level rise, the actual event occurrence may still be some way off, so information plays a significant role in highlighting risk identification; the question is what information is provided, how is it provided and how informed are the decision-makers of the risks? The risk lies in the information about the exposure of the property and how knowledgeable the purchasers are of the risks – perceived or actual. As found by Chivers and Flores (2002) the information asymmetry led to a market failure, where rational purchasers did not have sufficient information to make well-informed purchase decisions. Consequently, when considering the implications of sea level rise and escalation of flooding events locally, nationally and globally, the short-term and long-term effect on market values will be reliant upon information disclosure, processing of this information and in time, and in time response to events.

Current information pertaining to climate change and sea level rise is often variable and inconsistent and subject to political influence, which has affected strategic direction from different levels of government and variation in the confidence of property stakeholders to consider the implications of climate change and sea level rise risk for their properties. As a result, little has been undertaken in terms of creating short and long-term mitigation and adaption plans. Or in other words consideration of where they occupy property and how long they endeavour to persist with living or occupying or owning property in areas identified at risk.

An opportunity and key driver for change in the property sector will be through identifying properties at risk and property value implication from firstly sea level rise and then the varying degrees of risk from other cumulative flooding effects. As demonstrated in the flood literature (Beltran et al., 2018), floodplain identification demonstrates a significant discounting to housing values; consequently, through provision of better information to purchasers of sea level risk and flooding should be more accurately incorporated into pricing (Chivers and Flores, 2002). This will propel the need for more investigation and structures to assess risk and create risk minimisation strategies and adaption to minimise the future impact of these events. In time, understanding of risk, risk mitigation strategies and adoption approaches or lack thereof, will influence investment and occupation decisions within the sector leading to future implications for market value and insurable values. However, as demonstrated in the flood literature and Ortega and Taspinar (2018), recurrent events of inundation and frequency will likely be the strongest drivers of discounting.

This study sets out to demonstrate the relative implication of information asymmetry for a case study area, by examining the discounts associated with the floodplain identified areas compared to sea level rise inundation (where there is a lack of public disclosed information on a property specific level).

This study uses a unique combination of GIS database; planning and flood information; rating authority valuation data; and residential sales data to investigate the consideration of sea level rise and flood discounting in current value estimates for housing. Further examining knowledgeable actors in the market of flood plains (statutory valuers) and the market perception of discounts associated with flood prone properties or stigma of known areas (through sales data). The research sets out to firstly, ascertain whether mandatory provision of risk information, or lack thereof, has an effect on capital values (determined by statutory authorities) and sales prices (determined by market participants, purchasers). Secondly, examine whether properties identified as being at flood risk are discounted compared to non-flood risk identified properties.

Then utilising this information examines the implications of sea level rise information disclosure and existing flood discounts for property prices within a case study bayside municipality in Melbourne, Australia. Further, the study suggests the future implications of sea level rise inundation and increased flooding impacts on property values.

This research extends existing sea level rise studies to consider the broader implications of future flooding impacts on property prices; and contributes to the extant flooding literature in the combining of various datasets to minimise omitted variable bias, and repercussions of information asymmetry and its role in market failure. Further demonstrating the importance of government leadership in ensuring disclosure and adequate information is provided to purchasers in order for them to make well-informed decisions.

2. Research Strategy

To identify information asymmetry in relation to flooding and future sea level rise, an extensive dataset indicating property prices and attributes is required. Where flood designated properties are explicitly identified through council information and models, ensuring valuers assessing statutory values factor in the discount for floodplain property. For prospective buyers, at point of sale a Section 32 is provided which provides a visual plan of whether the property is in a designated flood zone or nearby one. At the time of this research, there was no statutory information provided to purchasers of sea level rise estimations or implications, however, sea level rise implications have been known to the council since the release of the Intergovernmental Panel on Climate Change (IPCC) reported and highlighted the potential of sea level rise and its effects (2007), which then spurred a response from governments and local governments. However, at time of this research there was not statutory declared information provided to purchasers of sea level rise risk.

This research uses a two-stage investigation strategy: firstly to examine whether the current flood designated areas and areas within the 2100 sea level rise estimations are discounted by the local authority rating valuations. The second stage will examine house price sales between 2011 and 2016 to investigate whether the market participants are identifying any discount associated with flood designated properties or sea level rise. The research investigates three hypotheses:

Hypothesis 1: Floodplain designated properties will be discounted compared to non-floodplain identified properties

Hypothesis 2: Sea level rise risk identified properties will be discounted compared to non-sea level rise risk identified properties

Hypothesis 3: Statutory valuers' assessment of flood risk identified properties discounts, as educated market observers more aware of the broader disadvantages of flood risk, will result in larger discounting applied than the general market participants.

Hypothesis 4: Mandatory provision of risk information will demonstrate a discounting effect on price, where no information is provided on risk there will be no effect.

This study utilises the case study area described in Warren-Myers et al. (2018) which details the modelling of sea level rise for the case study municipality. Utilising Geographic Information Systems to map and combine valuation based property data, sales data, LiDAR data for detailed elevation data, Warren-Myers et al. (2018) then used various existing sea level rise frameworks used in the Australian context to estimate sea level rise heights, high tides, storm surges and flood levels. In brief, the modelling comprises the well-known and used 'bathtub' approach (Geoscience Australia 2015a, 2015b; McInnes et al. 2015; and Hauer et al., 2016), wherein a digital elevation model is used and creates a cut of the topography and assumes the land is all the same. To identify the relevant hazard zones this study has used the Warren-Myers et al. (2018) model to identify sea level rise prone land and land to be affected by future flooding. To identify the hazard zones that cover current floodplain areas, this study has used existing flood overlays, which are based off historical data of low lying areas and flood event affected areas compiled by Melbourne Water and applied by the local authority in the local planning scheme. Identification of properties likely at risk in 2100 from sea level rise have been adopted from Warren-Myers et al. (2018) using Geographical Information System (GIS) model as primary identifiers.

Sea level rise from a property specific perspective has had varying attention academically and has tended to focus on the calculation of areas and population affected, then more recently specifically focusing on loss as a result of inundation or costs of either sea level protection adaptions or damage-based assessments and implications for property markets.

There are many studies that assess climate change impacts, in particular sea level rise on urban areas which examine the effects globally and locally, socially environmentally and economically. From a property specific perspective many of these studies calculate number of properties lost and populations at risk. The plethora of studies in this area spans several decades of research. However, the economic analysis studies undertaken over the past two decades in relation to sea level rise and property markets that focus on the vast economic implications are mostly focused on the United States.

The econometric studies using a hedonic modelling approach as an investigative technique can be broadly divided into the following categories: consideration of either the value add in the willingness-to-pay for protection or economic benefits provided through adaption measures (natural or manmade); and the value discount perspective, where the reduction in benefits for properties at risk is measured through a loss in value, which is a common approach to examine flood or disaster risk or damaged areas. In the context of sea level rise and property, there is a similar categorisation of the research, where market studies using scenarios with or without protection measures are examined in the context using a damage cost approach, and hedonic analysis to estimate the benefits of sea level rise risk reduction or discounting due to sea level rise risk.

The hedonic model method provides the basis for this approach, which is to estimate the implicit price of certain housing characteristics from the bundle of characteristics associated with the value purchasers place on a dwelling and its integrated neighbourhood features (Rosen, 1974). The utilisation of this approach is that through the housing market the isolation of an implicit value for certain attributes can be valued. This study employed the hedonic price model to estimate the economic loss as a result of flood identification and anticipation of sea level rise inundation or flooding as used by Fu et al. (2016), Bin et al. (2008, 2011), Rambaldi et al. (2013), Hamilton , (2007) Michel (2007). The general model of flood risk, where γ=hedonic price effect, λ=likelihood of damage, σ = the perception of risk, θ=time discounting, F=monetised flood damage, and ε=error term/unobservables.

$$P_{it} = \beta_n \sum_{n=1}^{N} X_n - \gamma * \lambda_i * \sigma_i * \theta_i \mathrm{F}_i + \varepsilon_i$$

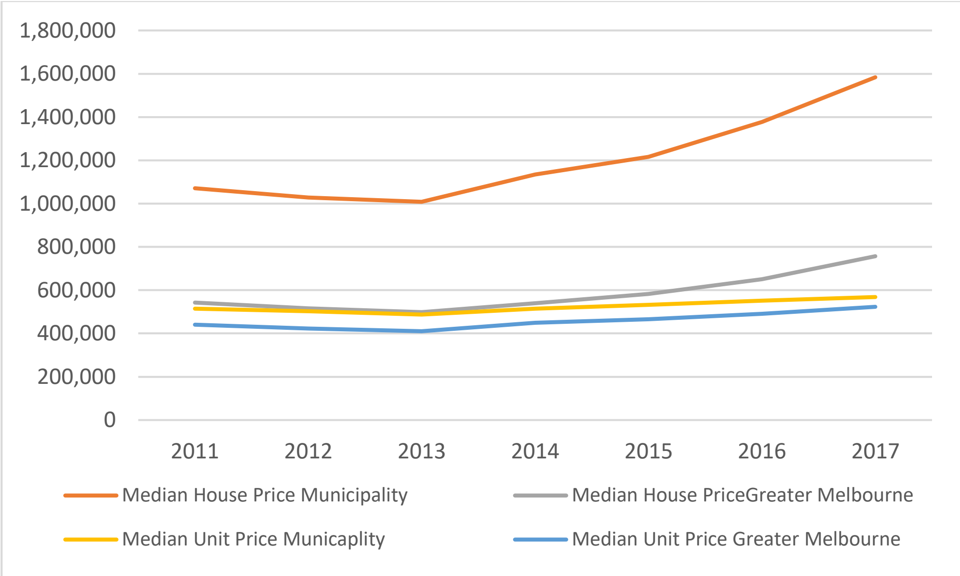
$$\Delta p_{it} = \hat{P} - \gamma * \lambda_i * \sigma_i * \theta_i \mathrm{F}_i + \varepsilon_i$$

There are a range of challenges to examining the implications of floodplain identification, where the hedonic price effect might be the error term or unobservables may correlate due to the endogeneity and omitted variable bias (OMV). In order to overcome these issues, we have taken a number of steps to ensure better matching and reducing the probability of OMV by limiting the area to the case study area, focusing on particular residential property types, and including a large number of relevant control variables elicited, particularly those that are suspected to be correlated with a flood zone location, coastal or canal/river frontage. Bin et al., (2008), Hallstrom & Smith (2005), Bin and Polasky (2004) and Shultz and Fridgen, (2001), all report a negative impact of flood zone location on the price of a dwelling. Bin et al. (2008), emphasise the need to disentangle positive and negative pricing factors of locations adjacent to water. This has been controlled for through the identification of properties that are identified as being water front, a distance from the waterfront and also canal frontage controls.

3. Data and Study Area

The data collected for this project comes from a number of sources providing vital and detailed information at different levels that endeavour to minimise the limitations observed in other studies. In particular, thoroughness in identifying as many descriptive characteristics of the properties, their spatial connectiveness, socio-economic, flood disclosure information, flood events and sea level rise information.

The data has been collected from a case study municipality that is situated close to the central business district in Melbourne and abuts the bay. The municipality had a population 2015 of 107,142 people (Australian Bureau of Statistics, 2017). The profile of this community according to SEIFA information (which is an index used to reflect disadvantage and consider low income, low employment, level of unskilled occupants and limited educational attainment); in the municipality is listed at 1069 on the SEIFA index scale in 2016, which by comparison puts it as one of the least disadvantaged areas in Melbourne (ID Community, 2018a). Which is further demonstrated in the comparison of the median sales prices in the municipality and that of greater Melbourne, shown in



Source: ID Community (2018b) City of Port Phillip Housing Prices

Figure 1. Median sales for municipality and Greater Melbourne

The information about the dwellings has been obtained through statutory valuation information which comprises thorough details about the properties; which go well beyond many of the other studies that have examined flood prone property. In particular, the data pertaining to the dwellings comprises the usual bedrooms and key features, but also dwelling age and renovation year, a quality of style code, quality of condition code, size of the dwelling and land and additional improvements to the dwelling or land, and views. Providing a comprehensive dataset of housing characteristics for analysis. In addition, this dataset also comprised the assessed values for the property on a site value, capital improved and net annual value basis for the 2016 rating year. We also have a sales dataset (January 2011 to December 2016) from Australian Property Monitor, which was matched to the property information from the statutory valuation set, to provide a second dataset with full dwelling characteristics for the study. Further, this information was then combined with other local government, geospatial data, GeoScience LiDAR elevation data. These datasets were connected to provide spatial calculations and distance to the coast/beachfront; the lake and parklands, schools, train stations and public transport stops and key retail destination areas within the municipality which were performed in RStudio and calculated using Euclidean distance and shown in kilometres.

The risk of flooding has been captured through the statutory planning overlays which specify whether a property is considered at risk of flood or situated in a flood plain, which has been used as a dummy variable. Further, spatial dimensions have been included for those properties not in a flood risk area but nearby through a GIS mapped measured distance. The flood risk overlays are determined by the local water authority in conjunction with the local government authority based on 1:100 year flood plain information and recent flood events. This provides the most reliable source in which to provide flood information to statutory authorities, residents and potential purchasers. An important consideration for this study is the information of flood risk is provided at the time of marketing by law in Victoria, through the Section 32 (Sale of Land Act Victoria). Potential purchasers are provided with the salient information about the property and are notified if the property is situated within a particular overlay and what it is, they are also provided with a map of nearby overlays. So potential purchasers are made aware of the flood risk or that there is flood risk close to their property, this is not only described but also includes a map.

Table 1 summarises key information for dwellings within the valuation dataset and Table 2 dwelling information for sold properties in the municipality. The tables report the means and standard deviations for salient hedonic characteristics used in the analysis, in particular building age, building size, number of bedrooms, quality and car spaces. Other amenities utilised in the analysis are included an expanded table in the Appendix. Examination of risk profile for the properties is assessed on a binary basis, whether a flood overlay is applicable for the property and then for the sea level rise, considers firstly just direct inundation at a 2100 sea level and secondly the sea level rise plus the new flood levels. Other key elements associated with whether the properties are located on the beachfront, and distance analysis of key neighbourhood amenities like the beach, parks, full service grocery store and retail areas, schools, healthcare and transport.

Table 1. Summary statistics for the valuation data

	Total sample		**Houses**		**Apartments and Units**	
	mean	sd	mean	sd	mean	sd
Capital Value 2016	$1,015,818	$882,295	$1,543,474	$881,388	$575,727	$366,204
Construction Year	1949	45.86	1915	41.01	1978	26.13
Building area (m2)	113.34	103.01	148.51	66.18	82.27	40.10
Bedroom (number)	2.26	0.90	2.84	0.79	1.78	0.66
Quality (scale 1 - 5)	3.07	0.45	3.05	0.47	3.10	0.44
Car space (1=yes)	0.77	0.80	0.62	0.70	0.93	0.86
Sea level rise risk (1=yes)	0.01	0.09	0.00	0.01	0.15	0.12
Sea level rise & flood risk (1=yes)	0.36	0.48	0.53	0.50	0.23	0.42

Flood overlay (1=yes)	0.14	0.35	0.16	0.36	0.13	0.33
Beachfront (1=yes)	0.05	0.23	0.02	0.13	0.09	0.28
Site is 400m from park (1=yes)	0.83	0.38	0.85	0.36	0.81	0.39
Distance to beach (km)	1.07	0.74	0.96	0.63	1.15	0.80
Distance to grocery & retail (km)	0.57	0.30	0.58	0.28	0.57	0.32
Distance to nearest childcare facility (km)	0.48	0.25	0.48	0.26	0.48	0.25
Distance to nearest pool or public recreation facility (km)	1.65	1.03	1.45	1.07	1.82	0.97
Distance to nearest healthcare facility (km)	0.67	0.30	0.65	0.30	0.68	0.30
Distance to nearest public Secondary School (km)	1.81	0.86	1.63	0.82	1.96	0.86
Distance to nearest public Primary School (km)	0.95	0.38	0.85	0.38	1.03	0.36
Distance to nearest rail station (km)	6.08	63.04	4.41	43.95	6.75	70.38
Distance to nearest tram (km)	0.42	0.33	0.44	0.34	0.41	0.33
Distance to nearest pharmacy (km)	0.57	0.33	0.64	0.38	0.52	0.27
N	37,091		16,640		19,539	

Table 2. Summary statistics for sales data

	Total sample		**Houses**		**Apartments and Units**	
	mean	sd	mean	sd	mean	sd
Sales Price	$905,899	$819,198	$1,318,038	$1,044,575	$625,588	$437,666
Construction Year	1945	49.54	1923	45.71	1970	41.23
Building area (m2)	147.55	238.53	149.04	98.36	145.87	332.22
Bedroom (number)	3.10	0.44	3.09	0.45	3.11	0.42
Quality (scale 1 - 5)	1.41	0.63	1.57	0.74	1.30	0.51
Car space (1=yes)	1.07	0.78	1.09	1.00	1.06	0.60
Sea level rise risk (1=yes)	0.01	0.09	0.01	0.10	0.01	0.08
Sea level rise & flood risk (1=yes)	0.33	0.47	0.45	0.50	0.26	0.44
Flood overlay (1=yes)	0.18	0.38	0.23	0.42	0.15	0.35
Beachfront (1=yes)	0.07	0.26	0.04	0.19	0.10	0.30
Site is 400m from park (1=yes)	0.87	0.34	0.86	0.35	0.87	0.33
Distance to beach (km)	0.94	0.00	0.00	0.00	0.00	0.00
Distance to grocery and retail (km)	0.94	0.71	0.90	0.62	0.96	0.76
Distance to nearest childcare facility (km)	0.54	0.29	0.58	0.28	0.51	0.30
Distance to nearest pool or public recreation facility (km)	0.51	0.24	0.49	0.25	0.52	0.24

Distance to nearest healthcare facility (km)	1.69	0.99	1.63	1.10	1.73	0.91
Distance to nearest public Secondary School (km)	0.67	0.35	0.63	0.32	0.69	0.36
Distance to nearest public Primary School (km)	1.70	0.85	1.59	0.83	1.78	0.86
Distance to nearest rail station (km)	0.98	0.40	0.89	0.38	1.04	0.41
Distance to nearest tram (km)	2.17	1.06	2.35	1.09	2.05	1.02
Distance to nearest pharmacy (km)	0.45	0.36	0.47	0.38	0.43	0.34
N	5313		2022		3291	

4. Results

Table 3 presents the results for the ordinary least squares regression models, the logarithm of the 2016 Capital Values estimated by the municipal valuers is regressed against their observable characteristics, including whether the property is identified as being a flood risk property or identified at risk under future sea level rise. The analysis is based on 36,863 residential properties in the municipality and the results present ordinary least squares regression models. Controlling for fixed effects for location, construction material and quality of building. The baseline model explains about 90% of the variation in the natural logarithm of home prices, which increases marginally when views, beachfront location and neighbourhood amenities are incorporated into the model.

As expected, larger properties and the higher the number of bedrooms command higher capital values. Whilst a negative effect is demonstrated for increasing age of the building. The mean age of houses in the municipality is 1915, which is reflective of the historic and heritage nature of the area; whilst the apartments and units have a mean age of 1978. As expected the construction year or age has a higher negative effect on the houses (4) than the apartments (5).

Main Results

The baseline model (1) identifies a significant and negative effect on capital values if the property is identified as being in a flood risk area. However, there is no apparent discount or negative effect in relation to future sea level rise. The extended model takes into account any views and whether the property is beachfront. As a common problem with studies that examine flood is the benefit of being beachfront and the exposure to risk this may have. Models (3) and (4) then consider the regressions for detached dwellings and flats and units. Model (3) shows the results for detached houses in the municipality, and as expected the sea level risk discount effect is not evident, demonstrating a positive value. However, the flood risk does demonstrate a significant effect, greater than the extended model (2). Suggesting that the effects of flood are felt more significantly in detached dwellings. This is certainly more apparent when compared to flats and units, where both sea level rise risk and flood risk demonstrate no discount at all. This maybe a presumption that apartments are not directly affected by flood, as they commonly do not comprise the ground floor.

Table 3. Regression results for Capital Values

Capital Value 2016 (ln)	(1) Naïve model	(2) Full model	(3) Detached	(4) Apts/Units
Under water if SLR=2.7m	0.434***	0.000203	-0.00506	0.0102**
Current flood zone overlay	0.143***	-0.0110***	-0.0215***	0.0150***
Year of construction (ln)		-2.381***	-0.717***	-1.690***
Building area sqm (ln)		0.606***	0.314***	0.687***
Number of bedrooms (ln)		0.136***	-0.0111*	0.136***
Land area sqm (ln)		0.0598***	0.406***	-0.0102***
Beachfront		0.0285***	0.215***	0.00914
Canalfront		0.0253**	-0.00359	0.0173**
Dwelling type	No	Yes	Yes	Yes
Construction materials	No	Yes	Yes	Yes
Quality of Style	No	Yes	Yes	Yes
Condition rating	No	Yes	Yes	Yes
Building Features	No	Yes	Yes	Yes
Location (suburb)	No	Yes	Yes	Yes
Views	No	Yes	Yes	Yes
adj. R^2	*0.084*	*0.940*	*0.894*	*0.924*
F	*1775.2*	*7958.5*	*1907.6*	.
N	*37008*	*36330*	*16400*	*19251*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 reports the results for the regression, comparable to the one undertaken on the valuation dataset; has a considerably smaller sample (n=3,068), which is to be expected when only considering sales within the municipality over a period of time. However, the model still explains about 70% of the variation in the natural log of sales prices. As the sales data is collected over a period of time, the timing of sale is controlled for in the regression analysis. The results reflect comparable direction of effect and significance; however, construction age has a stronger negative effect compared to the capital value analysis. Whilst building area has less effect in the sales than the capital value analysis; yet the number of bedrooms is substantially stronger in effect. This may be reflective of limited information pertaining to the size of the dwelling available to purchasers and the number of bedrooms being a quasi-indicator for purchasers as to the size of the dwelling.

In a similar vein to the capital value analysis, the sea level rise risk shows a positive and significant effect on sales price; suggesting firstly lack of awareness of risk and potentially other factors driving the positive result, which when neighbourhood characteristics are incorporated the sea level rise risk becomes insignificant, which suggests distance from the beach and other factors considered in model (3) control for. One of the interesting comparisons is the effect of flood risk, through the identification for the floor overlay between the capital values and sales. The flood risk is perceived to have a greater effect in the sales regression analysis than the capital values in models (1) and (2). Suggesting that the market, purchasers are pricing in the risk of flooding more so than the statutory valuers. However, when neighbourhood characteristics, in particular beachfront and canal frontage area controlled for the significance is lost in the sales although still demonstrating stronger effects and the sign of the coefficient is in line with other studies considering flood risk perspectives.

Table 4. Sales price regressions

Sale price (ln)	(1) Naïve model	(2) Full Model	(3) Detached	(4) Apts/Units
Under water if SLR=2.7m	0.360***	0.0391	0.0298	0.0125
Current flood zone overlay	0.168***	-0.0222	-0.0349	-0.0294
Year of construction (ln)		-4.458***	-3.869**	-3.021**
Building area sqm (ln)		0.133***	0.0326	0.0349
Number of bedrooms (ln)		0.513***	0.478***	0.568***
Land area sqm (ln)		0.00872	0.202***	-0.0233
Beachfront		0.0247	0.0492	-0.0208
Canalfront		0.109	0.165*	-0.0665
Dwelling type	No	Yes	Yes	Yes
Construction materials	No	Yes	Yes	Yes
Quality of Style	No	Yes	Yes	Yes
Condition rating	No	Yes	Yes	Yes
Building Features	No	Yes	Yes	Yes
Location (suburb)	No	Yes	Yes	Yes
Views	No	Yes	Yes	Yes
Year of sale	No	Yes	Yes	Yes
adj. R^2	*0.063*	*0.662*	*0.480*	*0.544*
N	*5206*	*3001*	*1423*	*1246*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Although these models utilise extensive building features, care of the descriptive summaries from the sales and the collated information from the statutory valuation database, there is likely still a possibility that other (unobservable) features in the dwelling that may be affecting the results. Consequently, we have also undertaken regression modelling of the land values. The land values for the sales dataset have been construed through estimating the value of the capital improvements care of the statutory information and extrapolating an estimated land price, referred to hereafter as 'land price'. The valuation dataset already had listed site values, which are referred to as 'site value' hereafter. Table 5 shows the ordinary least squares regression results with 84% explained in the variation of the natural logarithm of the land values; whilst 68% is explained through the variation of the natural logarithm of the construed land prices. The land prices model is a considerably smaller sample, based on the sales during the period 2011 – 2016 and as it's an analysis of the sales it is expected to have a lower R2 value. Both sets area controlled in terms of land size so as large residential development sites are not considered part of the analysis, and land with apartment blocks are excluded. Coefficients for the individual distance calculations to various neighbourhood characteristics, location clusters, fixed-time effects (for the sales) are not presented.

Both models 1 and 2 in Table 5 find a significant and negative relationship for land prices and values that are situated within a flood risk overlay. This supports the earlier models that also found a similar relationship, but when neighbourhood characteristics were included failed to be significant. By concentrating on the land alone, we can establish that the discount factor for flood risk properties is established in the underpinning site values and land prices even when location and neighbourhood characteristics are considered and controlled for. As noted in previous models, the flood risk is capitalised in the land prices more than the site values. As expected there was no indication of a negative relationship with sea level rise risk. Beachfront still commanded a significant premium in both models, of almost comparable levels, and the distance to the beach was again negative and significant desire to be near the beach.

Table 5. Regression of land price and land value

	(1) Site Value(ln)	(2) Land Price(ln)
Sea level rise risk	0.0110**	0.0196
Flood risk	-0.0230***	-0.0540*
Land area	0.00229***	0.00238***
Beachfront	0.283***	0.284***
Distance to beach	-0.000153***	-0.000208***
Neighbourhood characteristics	Yes	Yes
Year of sale	Yes	Yes
Land use	Yes	Yes
Location (suburb)	Yes	Yes
Land area<1,000m2	Yes	Yes
adj. R^2	0.844	0.684
N	16382	1262

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Robustness checks

There is considerable uncertainty around the expected extent of SLR globally and specifically on the Australian coastline. It is possible that the 2.7 metre reference scenario in the main results shown above, despite being supported by scientific climate modelling results, do not reflect the consensus of participants in the marketplace. Hence, it cannot be ruled out that no discount is found for properties at that level but a lower level of assumed SLR may yield different results. The first robustness check of the results involves re-estimating the full model of Table 3 with an SLR scenario of 1 metre. While the flood zone discount is very similar to the main results, the lower SLR scenario shows a premium rather than a discount, perhaps due to remaining unobservables in the vicinity of SLR-prone areas. In any case, it is confirmed that no discount exists even for areas that will be affected with a relatively high degree of probability. The second robustness check shown in Table 6 replaces current value with the percentage change in appraised value between 2014 and 2016. The results indicate that both currently flood prone properties and those potentially affected by a 1 metre sea level rise wer deemed to appreciate roughly in line with the general market or slightly higher. Hence, there does not seem to be any evidence that increasing awareness of SLR during recent years is reflected in appraisers' opinion of value.

Table 6. Robustness checks with 1 metre SLR and value change during the study period

Capital value	(1) SLR 1metre	(2) % value chng 14-16
Under water if SLR=1m	0.0694***	0.00887*
Current flood zone overlay	-0.0109***	0.00447***
FULL CONTROLS	YES	YES
R^2	0.940	0.699
adj. R^2	0.940	0.699
AIC	-30355.8	-100919.6
BIC	-29709.8	-100290.4
F	7953.0	1629.7
N	36330	36408

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Finally, we decompose the hedonic model of the sales transactions by year of transaction to examine changes over the five-year study period and detect any differences between appraised values and market transactions.. Figure 2 hints at lower or negative appreciation of properties in the SLR 1 metre area compared to all other properties. However, it is important to point out that the coefficients obtained for each year are not individually significant and thus have to be interpreted with caution.

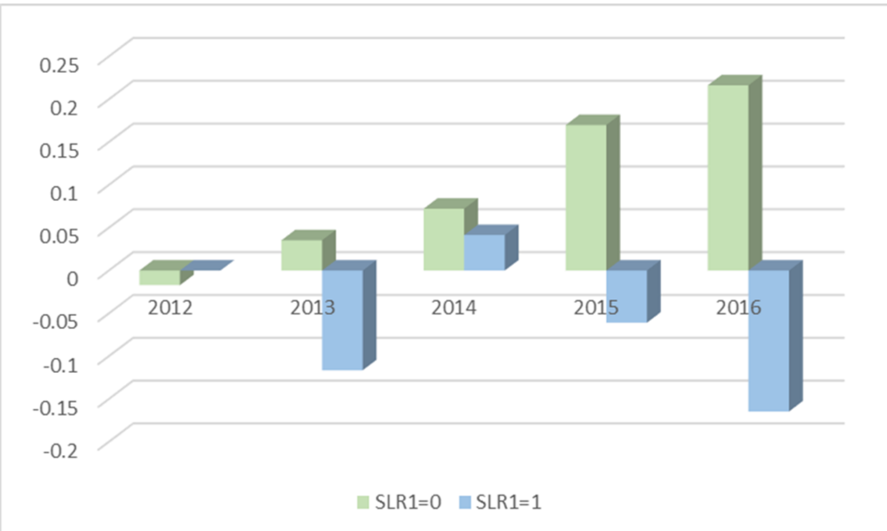


Figure 2: The effect of SLR on sales transactions by year
Note: full controls, reference category are 2011 price levels. SLR1=property affected by 1m sea level rise yes/no, results not significant at 5% level, green=properties outside 1m sea level rise area, blue=properties inside the 1m sea level rise area

5. Discussion

One of the main results of the hedonic pricing regressions presented above is that flood risk designated properties are discounted compared to non-flood risk identified properties. The model specification controls for a very large number of dwelling characteristics not normally included in residential regression analysis due to data limitations; locational and neighbourhood amenity elements; and the effects of premiums associated with beachfront coastal properties. Our models operationalise and applies these assumptions in the context of the municipality investigated, to seek out specifically whether flood risk and sea level rise risk are being taken into account. Our analysis confirms our first hypothesis, that *floodplain designated properties will be discounted compared to non-floodplain identified properties*.

What was found with certainty, that a negative relationship exists between flood risk designated properties and capital values, sales prices, site values and land prices, which concurs with the findings of Beltran et al. (2018) of discounts applicable to flood risk or floodplain designated land. Beltran et al. (2018) in their meta analysis concluded a 4.6% discount for floodplain designated properties; the results of our study demonstrate a discount between 5 – 8% for properties and between 2 – 5% discount in land value for properties identified in a flood risk area through the statutory authority planning overlays. Further, it would appear in our analysis that the market are discounting the flood risk higher than the valuers within the municipality. Making our third hypothesis null, and opposes findings by Harrison et al (2001) who found that tax assessors slightly over-assessed properties located in flood zones, relative to those in other areas. Suggesting there is a stronger stigma related to flood risk reflected in the price paid for a property in this municipality, when the purchasers are presented information that demonstrates the flood risk.

The second hypothesis of this study, that *Sea level rise risk identified properties will be discounted compared to non-sea level rise risk identified properties*, was found to have no significant results. On several occasions properties within the identified sea level rise risk areas had a positive and significant result. Suggesting that sea level rise is either not factored into decisions, or the market and purchasers are unaware of the risks.

As a result, this study results supports the final hypothesis, *Mandatory provision of risk information will demonstrate a discounting effect on price, where no information is provided on risk there will be no effect.* Discounting is clearly presented for flood risk designated properties, yet the lack of information relating to sea level rise leads to no discount evident and often a premium associated. In Victoria, all properties at point of sale, issued prior to the signing of the contract are issued with pertinent information about the property; at present this includes a map and description issued by the statutory authority, of whether the property is within a flood risk area. Consequently, purchasers are made aware of the implied flood risk of the property; and it is expected that a rationale purchaser would factor in and price the risk into the price paid. The analysis in our study demonstrates a discount associated with flood risk designated property; suggesting that purchasers are making pricing decisions in relation to the perceived risk. Concurring with Votsis and Perrels (2016), in that there is a strong importance of disclosure of information; which will then have subsequent effect and impact on property values when purchasers are made aware of the risks.

When examining whether SLR has an effect on prices and capital values; there is at present no empirical evidence to suggest there is a discounting occurring in relation to sea level rise. This is understandable in the context of sales prices, because at present consumers' are not provided with any information that might affect their decision-making in relations to sea level rise and the perceived risk to their property. Yes, the valuers perhaps should be considering the implications of the sea level rise implications for properties in the City of Port Phillip, if they are aware of the modelling and implications that might affect properties within the area. The lack of current information available to both potential purchasers, owners and valuers within the municipality could create future liability and responsibility issues in the future. Particularly, for the valuers' if they are not accurately reflecting the current markets' perception of flood risks of properties within the municipality; the estimation of SLR effect maybe much greater. This does have implications for policy implementation, as the market may have a stronger reaction and subsequently lead to a stronger discounting of at-risk properties.

There is a level of responsibility to provide purchasers, in this case, home purchasers, with information pertaining to the property both positive and negative. In Victoria, Australia, there is a requirement to provide a Section 32 which comprises information about the property, that includes a variety of information relating to planning, local authority valuation assessment of the property, rates payable, access to services and proposed road or transport changes that might affect the property. There is increasing need to communicate clearly the risks of sea level rise to the market. As sea levels rise gradually over the next 80 years; the flooding risk increases significantly within this area. Consequently, 40% of the municipality (Warren-Myers et al., 2018) will see increasing occurrence of floods, with expected value discounting likely. As demonstrated in this study, when the market is aware of the risks, this is factored into the prices paid. What is uncertain, is obviously how much and how quickly the sea levels will rise; and the effect of increasing extreme weather events and their occurrence may escalate the potential value discounting associated with properties near the coast, as an early indicator in Ortega and Taspinar (2018). Further, insurance companies may increase premiums in response, or be early instigators of demonstrating the risk of sea level rise and increased flooding through identifying properties as uninsurable. Which could then potentially lead to banks being unwilling to lend on uninsurable properties, further degrading the value of properties.

To product consumers, occupiers of coastal properties from future financial losses and potentially greater losses both direct and indirect; action is needed to provide purchasers and owners with clear understanding of the risk possibilities associated with property in coastal areas. Further, early awareness of the issue may provoke greater response from residents to consider not only mitigation actions, but start planning for adaptive actions that may take years and considerable sums of money to fund. Which while property values remain relatively unaffected, may mean that it is time for governments to act now in shoring up future income streams to fund adaption options.

6. Conclusions

What has been apparent in the Australian environment has been, be it flood or fire, the increasing frequency of substantial precipitation, extreme storms and winds, creates both short-term discounts and long-term impingement on capital growth. Consequently, it can be considered the effect of sea level rise will have a significant effect on properties' value, those directly affected will face heavy discounting and subsequent total loss; and those properties not directly inundated will face the costs and losses associated with increased flooding. Future changes to regulation, legislation or even environmental considerations will affect: the Highest and Best Use; development opportunity and costs; insurance premiums; financing costs; depreciation; changes in tenant demand and occupancy; and increases in maintenance, statutory reporting and refurbishment costs; all of which will ultimately affect property values. Further, in consideration of the anticipation of sea level rise and increased flooding will likely result in increases in the number of uninsurable properties and increases in insurance premiums and regulatory measures for those partially affected or within the region. To gain greater understanding of the likelihood of the impact on property, measures need to be put in place to identify, ascertain and quantify risks in order to demonstrate strong reasoning for implementing mitigation and minimisation strategies for property assets. By connecting the value to the profiling of sea level rise risk identification process, this can be considered by property stakeholders and governments and result in subsequent action; however, these stakeholders need to be able to understand and quantify the risks posed.

This research makes a significant contribution in the Australian environment in demonstrating the need for clear policy and legislation to make purchasers, owners and occupiers aware of the risks associated with their property. Further, demonstrating the current information asymmetry and the implications this has for long term property values; where sea level rise risk cannot be priced by market due to a lack of awareness and information provided. This study highlights that the market does identify and make decisions based on the risk profile of properties and this is seen through the prices paid for flood risk designated properties in this study. Consequently, if the market is to determine for themselves the risk and subsequent price effect of sea level rise; clear information is paramount for the market to utilise in decision-making.

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