Housing shadow prices in an inundation prone suburb

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Abstract

For urban areas already exposed to flooding risk, the prospect of increased population densities and of more frequent extreme weather associated with climate change is alarming. Proactive adaptation, including changes to planning schemes, can reduce the risks faced in such urban areas. However empirical information detailing the benefits of proactive adaptation is limited. Further, in order to engage and motivate residents within exposed areas to participate in any adaptation, how (and when) adaptation measures will impact on individuals need to be understood. To inform such thinking, we present here a detailed case study of climate adaptation to inundation. We present a hedonic approach that evaluates property values and preferences in an inner city suburb in Brisbane, Australia, which contains areas that are in a floodplain. Using a dataset specially constructed by the authors, the study defines a continuous effect of flooding such that discount on property prices depends on its vertical distance relative to its 1-in-100-year flood level. The discount is of the order of 5.5% per metre below the 1-in-100 year flood level. Due to the detailed hedonic characteristics included in the dataset, the study also provides estimates of the shadow prices of housing characteristics and distances to amenities (such as bus stops, train stations, parks and bikeways). Such factors need to be considered when holistically assessing the dynamics of urban areas in response to planning changes.

1. Introduction

As population densities in urban areas increase, the potential losses due to flooding events can have major economic impacts (Guofang et al. 2003; Hallegatte and Corfee-Morlot 2011). Climate change compounds the risks from flooding, as sea levels rise and the extreme events occur more frequently. Proactive adaptation can help manage urban flooding risks (Wang et al. 2010). However proactive adaptation requires buy in from the community. People's wealth is largely tied up in the family home. In Australia, for example, residences account for approximately 40% of personal net worth (Wilkins et al. 2009). How willing residents might be to engage in longer-term adaptations to current and future climate risks will depend on the implications for their net wealth. We use hedonic modelling to uncover the longer-term flooding price signal for residential homes. Hedonic modelling has an extensive history in urban studies (Ball; Debrezion et al. 2011; Duncan; Kang and Cervero 2009). We extend this research by exploring flood related price discounting along a continuum of risk, such that the impact could be scaled to consider future climate.

Past studies have shown that the impact of flooding is multifaceted, and varies with scale and according to the degree of social inequality and disruption. Baade et al. (2007) contrasted Hurricanes Katrina (New Orleans 2005) and Andrew (Miami 2002). Despite US$100 and US$20.8 billion damage bills for Katrina and Andrew, both events provided local economic stimulus with rebuilding efforts funded by public and private insurance. Longer-term recovery, it seems, is determined by the degree of social inequality and the lack of adaptive capacity in disadvantaged subgroups. Recovery after Katrina was relatively more problematic than after Andrew in this regard (Rhodes 2010). The comparison points to the need to consider the distribution of flooding impacts when planning adaptation measures.

In this paper we explore the city of Brisbane, Australia. In January 2011 Brisbane and other regions of the State of Queensland experienced major flooding which caused shrinkage of the Australian economy by 1.2% (ABC News, 1 June 2011). Past studies have focused on physical infrastructure (Hall et al. 2003; Hall et al. 2005; Wang et al. 2010). For insurers, governments and industries reliant on infrastructure assets, this is the key measure of impact. In exposed urban areas, residents feel the impact from both damage to their residences, and

also via discounting to their land values. After the Brisbane floods individual land valuations were reassessed, some dropping by up to 20%, with consequent reductions in local council property taxes (Bray 2011). In planning pathways for adapting to the increased risks of flood and coastal inundation related to climate change, and in particular in engaging communities, these economics need to be understood.

Price discounting as a consequence of flooding has only been studied using hedonic analysis of market prices on a small number of occasions, including studies in the U.S. (Bartosova et al. 1999; Donnelly 1989; Park and Miller 1982; Thompson and Stoevener 1983; Shultz Bin and Kruse 2006b; Bin et al. 2008; Shultz and Fridgen 2001;), Europe (Daniel et al. 2009), and Japan (Guofang et al. 2003). Most of these studies attempt to estimate the effect of flooding on residential or commercial prices in the few years immediately following a major event. While hedonic models have been applied to Australian urban systems (Hatton MacDonald et al. 2010; Higgins et al. 2009; Tapsuwan et al. 2009) none have explored the impact of urban flooding. Only simpler statistical analyses of the effects of flood risk on house prices have been conducted in Australia, partly due to paucity of data (Eves 2002).

Internationally, previous studies generally found that location within a floodplain significantly reduces the property values by 5 - 10% relative to similar flood-secure housing in the same area (Bartosova et al. 1999; Bin and Kruse 2006a; Donnelly 1989; Guofang et al. 2003; Speyrer and Ragas 1991; Thompson and Stoevener 1983). Other studies found small or no responses (Shaefer 1990) in situations where decreased values due to coastal flood risk are confounded with increased amenity due to coastal proximity (Bin and Kruse 2006b), or when the time since the last major flood events exceeds the market 'memory' (Bartosova et al. 1999). Very few authors have considered continuous measures of flood risk, such as inundation depth during a 1-in-100-year event, as a continuous driver of value loss in flood prone properties (Bartosova et al. 1999).

Some authors have questioned the power of hedonic analyses to analyse historical sales records to estimate the real market-valued costs of flooding because such a conclusion relies on the market's dubious ability to price high-consequence, low-probability risk (Bouma et al. 2005). However, where the question to be asked is related directly to the market's response to flood risk, hedonic analysis is an optimal method as it measures market valuations directly.

Forward-looking climate change studies, for instance, are beginning to explore how flood risk may affect land prices directly (Bin et al. in press).

Hedonic analyses require a great deal of explanatory data in order to adequately decompose individual properties into the factors that explain variation in prices. Furthermore, data tend to come from disparate sources, and most data are costly to purchase, clean and digitize where required. In Australia, a significantly reduced variety of data are stored by local councils, requiring particular attention to synthesis of datasets from multiple sources.

This study analyses a purpose built dataset which includes flood risk for individual properties, assessed based on vertical meters above observed past flood levels. This allows us to explore the price discounting along a continuum of flood risk. This paper defines a flood pain effect as a function of two parameters within a hedonic model with spatial effects. We present empirical estimates of this effect as well as estimates of the shadow prices of other characteristics. Our data are for a suburb in the city of Brisbane, Australia. Brisbane suffered a major flooding event in 1974 and 2011, yet ours is the first study that provides estimates of the shadow prices.

2. Methods and data

In the context of this paper, the hedonic function is a model of buyer's willingness to pay for land or the bundle of land with a structure (detached house). Further, we are concerned with estimating the decrease in value due to the property being in the floodplain.

Sales data

Our model (below) uses various hedonics to explain instances of residential property sales. Our dataset contains 3944 residential properties sales including 87 vacant land sales. Many properties were sold more than once in our sample period, and our sales data relate to records from 1610 properties. As the dataset is from a single suburb, there is some unavoidable homogeneity, e.g. the majority of the structures are either pre-war or post-war (the year 1946 marking a change in local architecture). Figure 1 shows the distribution of sales for each year

in the 1970 -2010 sample, although the data set ends in the first quarter of 2010. Note that our data does not include any sales after the 2011 major flooding in Brisbane.

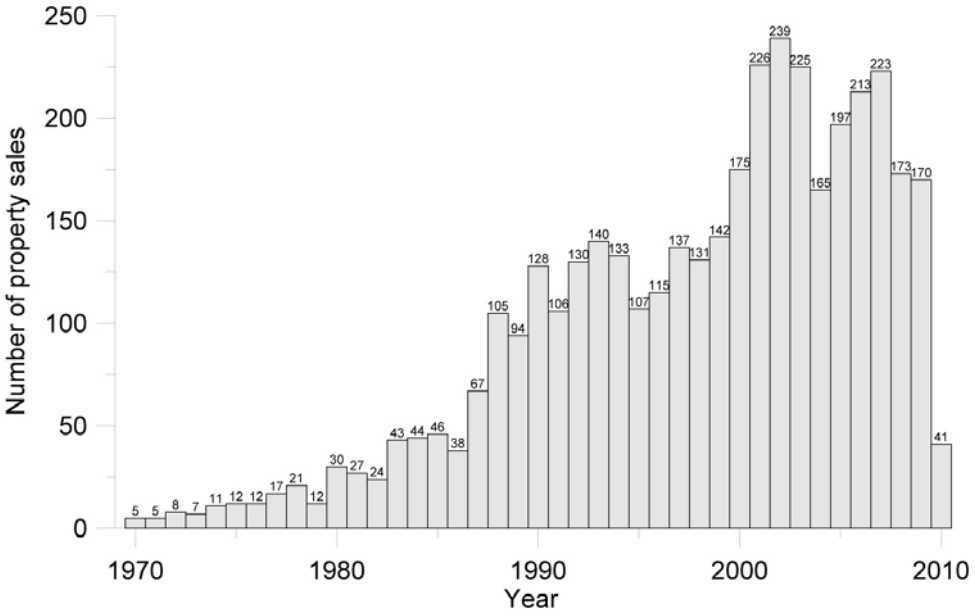


Figure 1. Distribution of sales data used by hedonic model

We use commercially available property sales data, including sale date, sale value, street address, size of the lot (land size) and a series of attributes (RP Data Ltd). These data were combined with local government geospatial data, aerial imagery and terrain characteristics to estimate the structure's age, and proxy the structure size. Only normal property sales (all other sales, such as gifted or partial sales were excluded) with a land use description of vacant land (i.e. Vacant – large house site and Vacant – urban land) or dwelling (i.e. Dwelling – large house site or Single Unit Dwelling) were used.

Substantial cleaning was required to remove obvious errors from the commercially provided data. This process involved cross checking against additional data sources including local government sources (e.g. the local council's property planning and development website – http://pdonline.brisbane.qld.gov.au/), other real estate data sources (e.g. www.homepriceguide.com.au APM 2010, and www.realestate.com REA 2010) and aerial imagery sources including images supplied by the local government and online sources such

as Google Earth (using its Historical Imagery feature) and Google Street View (see Appendix for more detail on data cleaning). Once cleaned the dataset was combined with numerous other information sources, such as geospatial data and aerial imagery to build a more comprehensive set of hedonic characteristics (below).

Our model

The econometric model used for estimation is the well established time dummy hedonic model,

$$\ln Price_i = \beta_0 + \sum_{t=1971}^{2010} \delta_t D_{it} + [\theta_1 F_i^D + \theta_2 F_i^D F_i^L] + \sum_{a=1}^{19} \beta_a X_{a\ 1} + \epsilon_i$$

The D_{it} is a dummy variable that takes the value of 1 if property sale *i* occurred in year *t* and zero otherwise. We detail the explanatory variables X_a below. Most critical here is $[\theta_1 F_i^D + \theta_2 F_i^D F_i^L]$, which is the 'floodplain effect'. F_i^D is a dummy variable that takes the value of 1 if property *i* is in the floodplain (defined in this study by whether the difference between the 1-in-100yr flood level and the minimum parcel height is greater than zero), while F_i^L is the vertical distance between the minimum ground level of the parcel of land (see Table 1) and the 1-in-100yr flood level for that parcel of land.

Hedonic models are usually estimated in linear or log-linear (semi-log) forms. We estimated both log-linear and linear forms and found the marginal effects to be comparable when evaluated at the mean prices. Hence we choose to use the log-linear specification which has advantages in terms of interpretation. The slopes (marginal effects) and elasticities of characteristics are a function of price and therefore they change over time with sale values. In the log-linear form the coefficients can be easily interpreted as the proportional change in the price given a one-unit change in the characteristic. This allows us to interpret the floodplain effect as a percentage impact on the value of the property.

Table 1. Data, variables and sources

Data	Description	Sources/Notes
Price ($)	Observed Price of Sale of the Property	RPdata.com (http://www.rpdata.net.au/) (RP)
Latitude and Longitude	Geographical coordinates of property address	RPdata.com (http://www.rpdata.net.au/) (RP)
Land Area (m^2)	Size of the lot or parcel	RP and Brisbane City Council (BCC)
Structure Area (m^2)	Footprint of the house	DERM (LiDAR) 2010
Land parcel height (m)	Minimum & maximum levels above sea level	DERM (LiDAR) 2010
Flood levels (m)	1-in-100 yr flood level for property	Publicly available BCC
Distances (km)	Distances to key spatial features (river, industry, train, bikeway, bus stop, parks, school, shops, waterway, central business district)	BCC and Geospatial tools
Era-Age of the Structure (Age)	Pre-War (1942 in sample); War&Post-War (1462); Late 20th Century (290); Contemporary (168). Building eras definitions (a).	RP, BCC Planning and Development Online (http:// http://pdonline.brisbane.qld.gov.au/), Google View or www.realestate.com
Bedrooms (Bed)	Number	RP, BCC Planning and Development Online, or www.realestate.com
Bathrooms (Bath)	Number	RP, BCC Planning and Development Online, or www.realestate.com
Undercover Car Spaces (Car)	Number	RP, Google View or www.realestate.com
Levels in the Structure (Levels)	Number	Google View or www.realestate.com

(a) Google Street View or www.realestate.com
Wicox, L. (2009) Housing Styles, http://www.hotpropertyspecialists.com.au/articles/housing-styles.html
Apperly, R., R. Irving, P. Reynolds (1995) "A Pictorial Guide to Identifying Australian Architecture; Styles and Terms from 1788 to the Present". Angus & Robertson Sydney; Australian residential architectural styles, http://en.wikipedia.org/wiki/Australian_residential_architectural_styles;
Home, Brisbane Style. In: Brisbane Between the Wars – A History by Design. http://www.library.uq.edu.au/fryer/brisbane_btw/page5.html;

We define the floodplain effect on the property associated with sale *i* in the floodplain as

$$FloodPlainEffect_i = \begin{cases} (\theta_1 + \theta_2 F_i^L) \times 100 & F_i^D = 1 \\ 0 & F_i^D = 0 \end{cases}$$

We model the error structure as a Spatial Error Model (SEM). This model assumes any spatial dependence results from omitted hedonic characteristics and is thus captured through the unobserved component of the model, ε_i. The SEM model is

$$\varepsilon_i = \rho \sum_{j=1}^{N} w_{ij}\varepsilon_j + u_i$$

where,

$u_i \sim N(0, \sigma^2)$

$w_{ij} = \begin{cases} \neq 0 & if\ i\ and\ j\ are\ neighbours \\ = 0 & otherwise \end{cases}$

$|\rho| < 1$ is a spatial correlation parameter

Thus, the w_{ij} are the elements of a row-stochastic spatial weights matrix, W, with diagonal elements equal to zero. In this study neighbours are determined using a Delauney decomposition. To form the spatial weight matrix, a measure of contiguity or nearest neighbours is needed. Eucledian distances are intuitive; however, they can be computationally burdensome. A more elegant and computationally less intensive approach is to use computational geometry. In this paper the nearest neighbours are computed using a Delaunay triangulation. A detailed exposition of Delaunay triangulations can be found in LeSage and Pace (2009) Section 4.11. When W is derived using Delaunay triangles, it represents the nearest m neighbours, W^2 represents neighbours to neighbours, and so on.

Explanatory hedonics

The econometric specification of hedonic models is highly dependent on available data (see Sirmans et al. 2005 pp. 5-6). Although a very large number of hedonic attributes can be included in a hedonic function, it is clear that some are more crucial than others (Sirmans et al. 2005). For instance, houses are durable assets and as such undergo a quality change over time (depreciation); however, without information on the age of the structure (year of build) the hedonic function could be severely mis-specified. On the other hand, lack of information on the type of roof is unlikely to induce large biases.

The explanatory hedonic characteristics used in our study are presented in Table 1, with descriptive statistics in Table 2. The dataset were constructed by merging commercial individual transaction records with government spatial data. As a result, very detailed hedonic characteristics are included in the dataset, and thus the study also provides estimates of the shadow prices of housing characteristics (such as bedrooms and bathrooms), structure (extra square metre in size of the structure), land (extra square metre in land size) and of the distance to several amenities (such as bus stops, train stations and schools).

The age of the structure (i.e. the year it was built) is a key variable but one often not available in Australian datasets[1]. Only around 7% of the commercially purchased dataset records were supplied with a build year. To establish a proxy for build year/age of the structure online sources, largely Google Street View, were used to view each property and determine, through expert knowledge, a build era (see Apperly et al. 1994; The University of Queensland 2010; Wikipedia 2010; Wilcox 2009). The identified eras were pre-war (pre-1946), post-war (1946-1960), late twentieth century (1960-2000) and contemporary (2000 onwards). At the same time, this process was also used to collect the additional hedonic characteristics of number of levels of each structure and the building and roof material of each structure.

Geospatial data were used in the determination of the distance of properties to key amenities (e.g. parks, train stations, schools, and waterways), their minimum and maximum ground levels, and the footprint of each structure. All spatial calculations were done using the ESRI ArcGIS platform. Distances to key amenities were calculated using the Euclidean distance. This was a measurement of the straight-line distance from the centroid of each land parcel to the closest object of interest, such as a park, train station, bus stop, school, the coastline or a waterway. The minimum and maximum ground levels of each land parcel were determined from a digital elevation model (DEM) at a spatial resolution of 5 m created from LiDAR data (DERM 2010).

[1] The exception is South Australia where the government collects: No. of Rooms, Year Built, Period Built, Equivalent Area, Purchaser Type, Heritage Type, Government Sales Condition, Roof Type, Wall Type, and Style, although these fields are not always populated. This information was provided to the first author by Tim Lawless from RPData.

Table 2. Descriptive Statistics

	Min	**Max**	**Median**
Price (current $)	$2,600	$4,710,000	$215,000
Land size (m^2)	181	2218	607
House size (m^2)	44.96	1000	174.20
Parcel of land's minimum height above sea level (m)	0.084	80.625	20.107
Distance amenities (kilometres): Brisbane River; Industry; Train station; Bikeway; Bus stop; Parkland; School; Shops; Waterway; CBD.	0.952; 0.000; 0.014; 0.010; 0.011;0.005; 0.040; 0.00; 0.005; 2.461	4.774; 2.616; 3.169; 1.506; 0.504; 0.563; 1.234;1.089;1.624; 5.770	3.045; 0.910; 1.404 0.560; 0.181; 0.159 0.445; 0.331; 0.526; 3.967
Number of Bedrooms	0	6	3
Number of Bathrooms	0	3	1
Undercover Car Spaces	0	5	2
Levels in the Structure	0	2	1

3. Results

Maximum likelihood estimates of the model are presented in Tables 3 and 4. The estimates were obtained using Matlab's Spatial Econometrics Toolbox. The functions 'fdelw2.m' and 'sem.m' were used. The 'fdelw2.m' function was used to construct the spatial weights matrix and the 'sem.m' function was used to obtain the parameter estimates. The estimate of ρ is highly significant indicating a moderate degree of spatial correlation within the sample. The R^2 for the model indicates 92.1% of the variation in the log of sales prices can be explained by variation in the explanatory variables.

Table 3. Time-dummy spatial error model – Time dummies

Explanatory Variables	Estimate	StdErr	t-stat
D1971	-0.333	0.106	-3.157
D1972	-0.170	0.081	-2.106
D1973	0.249	0.087	2.853
D1974	0.198	0.066	2.993
D1975	0.478	0.064	7.501
D1976	0.572	0.063	9.022
D1977	0.754	0.050	15.118
D1978	0.730	0.043	17.158
D1979	0.737	0.063	11.617
D1980	0.804	0.031	26.217
D1981	1.007	0.035	28.862
D1982	1.167	0.038	30.660
D1983	1.313	0.017	76.984
D1984	1.320	0.015	85.632
D1985	1.353	0.013	103.31
D1986	1.366	0.022	62.932
D1987	1.456	0.017	84.476
D1988	1.768	0.023	77.227
D1989	1.935	0.022	89.001
D1990	2.032	0.026	79.262
D1991	2.145	0.024	90.584
D1992	2.222	0.026	85.542
D1993	2.237	0.026	84.620
D1994	2.315	0.026	88.079
D1995	2.277	0.023	97.541
D1996	2.278	0.025	91.371
D1997	2.361	0.026	89.229
D1998	2.379	0.026	90.945
D1999	2.455	0.027	91.409
D2000	2.527	0.029	87.519
D2001	2.764	0.030	92.418
D2002	3.038	0.031	99.482
D2003	3.253	0.030	108.808
D2004	3.340	0.029	116.467
D2005	3.370	0.031	109.586
D2006	3.408	0.030	113.190
D2007	3.620	0.031	116.003
D2008	3.660	0.030	122.392
D2009	3.664	0.030	123.265
D2010	3.788	0.015	247.033

Flooding

The floodplain effect estimates are $\hat{\theta}_1$ = -0.0128 and $\hat{\theta}_2$ = -0.0545. As the model is log-linear the estimates can be interpreted as the proportionate change in the price due to an absolute change in the explanatory variable(s). Figure 2 presents a plot of the estimated price discount due to the floodplain effect based on these estimates. For instance, all else being equal, a property with its lowest ground level one metre below the 1-in-100yr flood level is expected to have a discount of 6.72% on the sale price because of flooding. For a property with its lowest ground level at the 1-in-100yr flood level, its sale price will be discounted by 1.28% because of flooding. The t-statistics for $\hat{\theta}_1$ and $\hat{\theta}_2$are -0.3703 and -1.5487. While individually neither are significant, jointly they are significant at 5% (likelihood ratio of 7.895)

Table 4: Time-dummy spatial error model – Explanatory variables

Variable	Coefficient	s.e.	t-stat
Intercept	7.540	0.115	65.43**
House size (m^2)	0.001	0.000	8.282**
Bath (number)	0.104	0.009	12.254**
Beds (number)	0.045	0.006	7.054**
Cars parks (number)	0.002	0.006	0.363
Level (number)	-0.026	0.011	-2.271*
Land size (log m^2)	0.373	0.017	22.585**
Dummy			
Pre−War house	0.058	0.010	5.693**
Late20th house	0.049	0.018	2.802**
Contemporary	0.234	0.022	10.505**
Flooding			
Dummy (F_i^D)	-0.0128	0.035	-0.370
Level (F_i^L)	-0.0545	0.035	-1.549
Distance from measures (kms)			
Brisbane River	-0.144	0.044	-3.244**
Industry	-0.299	0.050	-5.964**
Train station	0.596	0.056	10.648**
Bikeway	-0.097	0.023	-4.231**
Bus stop	0.173	0.045	3.823**
Park	-0.125	0.050	-2.527**
Schools	-0.071	0.033	-2.192*
Shops	0.023	0.031	0.758
Waterway	0.071	0.025	2.833**
CBD	-0.188	0.021	-8.953**
Model fit			
$\hat{\rho}$	0.340	0.008	44.765**
ln L	1261.179		
$\hat{\sigma}^2$	0.061		
R^2	0.921		
N	3944		

For coefficients: * significant at 5%; ** highly significant at 1%

In order to draw comparisons to previous studies we also re-estimate the model excluding the interaction term $F_i^D F_i^L$. This yields a new estimate of $\hat{\theta}_1 = -0.0534$ which is highly significantly (t=-2.3622). Overall the results indicate that properties in the floodplain are subject to significant price discounting when all other considerations (i.e. other hedonics) are accounted for.

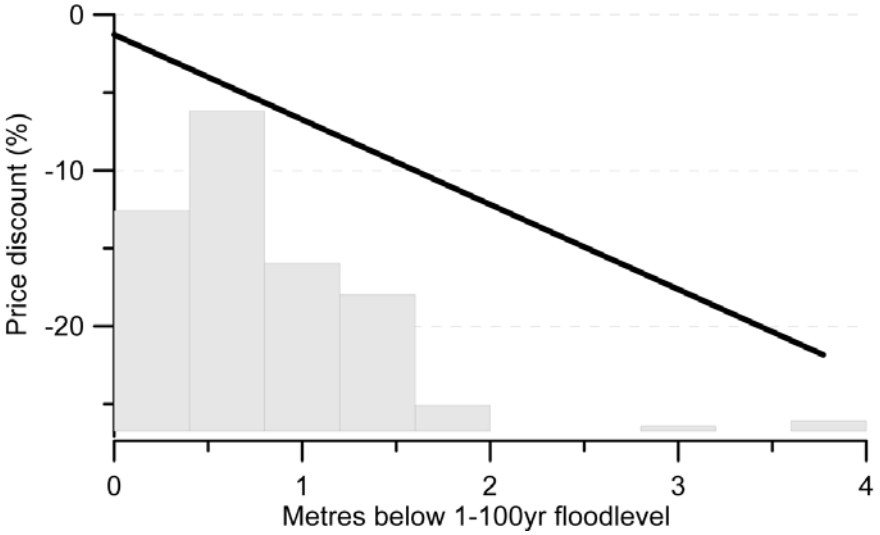


Figure 2. Estimated relationship between the degree of price discounting and the vertical distance of a property below the 1-100yr flood level. The histogram indicates the percentage of housing sales exposed across vertical distance levels (note only 169 of our total sales data are represented in the 1-in-100yr floodplain).

Other hedonics

Beyond flooding, all variables included in the model are significant except for the number of carport spaces and distance to shops. Given that the case-study suburb is very close to the centre of the city (CBD) and is well served by public transport and shopping outlets this finding might not be unexpected. The remaining distance variables are all significant. All signs are as expected, except for the distance to industry which is negative, suggesting properties closer to industry are more valued.

As mentioned the log-linear model shows the proportionate change in price due to an absolute change in explanatory variables. Hence our results show an extra bathroom increases the price of the property by 10.4% and an extra bedroom by 4.5%. There is a decrease in the value of the property of 14.4% per kilometre of distance to the Brisbane River, while the decrease is of 12.5% per kilometre of distance to a park. An increase of one percent in land size results in an increase in the price of the property of 0.373%.

Dummy variables show that a Pre-War style home is 5.8% higher in value than a War/Post-War home (War/Post-War homes being the base assumption in our model). This is a vintage effect which has been referred to in the real estate literature (see Sirmans et al. 2006 for

discussion). Homes built in the late twentieth century are 4.9% higher in value than those built in the War/Post-War era, while contemporary homes (built in the last 10 years) are 23.4% higher in value than those built in the War/Post-War era.

The time-dummy coefficients can be interpreted as indexes (for details see for example Hansen 2009) and a chained index can be constructed (for details see Rambaldi and Rao 2010). From our results we estimate average annualised property growth of 7.8% between 1970 and 2010. This is not adjusted for inflation, and otherwise is likely driven by land prices due to the proximity of the suburb to the CBD. We also compared our sales data to official government valuations published by the Queensland Government. For 170 properties sold in 2009 and 37 in 2010, government land valuations averaged 69.7% and 62.3% of the observed sale value in our dataset. This suggests that in our case study area land comprises the major share of property value.

3. Discussion

The study uses a hedonic approach to evaluate the willingness to pay for a property (land and structure) in an inner Brisbane city suburb which contains areas that are in the floodplain. The approach we applied is data intensive and provides for a variety of results on what residents value. However our purpose is to use the hedonic housing features such that we can more accurately isolate the impact of flooding.

The sample used in this study includes 3944 properties sales. Of these 169 relate to sales of properties with their lowest ground level below their 1-in-100yr flood level. Using our specially constructed dataset, the study defines a continuous *effect of flooding* such that the discount in the property price depends on its vertical distance below the 1-in-100yr flood level.

The city of Brisbane and its surroundings is one of Australia's fasted growing regions. It is also coastal and low-lying and the combination of exposure and impacts led the Intergovernmental Panel on Climate Change (IPCC 4th Assessment) to identify the region as an international vulnerability 'hotpot spot' for flooding, storm surges and sea level rise. Our

results are for a suburb subject to storm and river flooding and indicate that for every property exposed to 1-in-100yr flooding, prices have a significant discount, all else being equal. This finding is consistent with international studies (Bartosova et al. 1999; Bin and Kruse 2006a; Donnelly 1989; Guofang et al. 2003; Speyrer and Ragas 1991; Thompson and Stoevener 1983). Furthermore, for our case study we show that for every vertical metre a property is below the 1-in-100yr mark, additional discounting applies. We showed that every vertical metres leads to a further of 5.45% price discount.

Our results analyse hedonics that are already embedded in the local housing market, and we look at the long-term impact of flooding rather than the impact of a flood event. These highlight major issues for regional planning in the context of climate change. Further, the city of Brisbane is young by European standards (cira1840s). The past 100 year have been quiet in terms of major storm activity (cyclones/hurricanes) (Levin 2011). Hence, climate change or not, it is possible the hedonics of flooding that are built into prices are overly optimistic. In future climates the region is likely to experience increased extreme events and flooding, and planning in existing, flood-prone areas is the real crux for adaptation in the region. (Wang et al. 2010)

Yet planning needs to consider more than just flood mitigation, and our results also talk to the dynamics of changing suburb structures. House prices decrease with distance from parks. Staged resumptions of exposed housing are an opportunity to create additional green space which will improve the hedonics for some residences. Likewise, newly created green spaces could facilitate bikeways which also significantly boost values. The suburb dynamics created by resumptions will also have impacts for density and the feasibility of transport and shopping options, all of which need to be balanced when thinking about the economic motivations for land holders, and the economic and social feasibility of policy.

Planning for climate risks, particularly under future climate change scenarios, will require multi-level governance frameworks which involve governments across scales, industry and the community (Funfgeld 2010). A great deal of conceptual research has explored the need to build multi level urban governance and networks across cities (Betsill and Bulkeley 2006; Bulkeley and Betsill 2005; Bulkeley and Kern 2006). Empirically, studies are emerging that look at the private sector interest in urban governance (e.g. Cook 2009; Koppenjan and Enserink 2009; Moore and Bunce 2009; Taylor et al. in revision). In developing a detailed

empirical case study of how the risks of flooding impact on personal wealth our research builds a platform from which to examine state and community interactions. The implications for, and interactions with, residents in urban areas is the motivation this paper. How motivated urban residents are to engage in governing climate adaptation will need to be informed by when and where the costs and benefits of adaptive responses manifest.

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Appendix 1

While our main data cleaning approaches are outlined in the main body, here we outline additional checks used to ensure data quality:

- 'PD Online' is an online database that enables the viewing of council planning applications and approvals. Its structure and the information that it provides varies from council to council. Our case study area contains many properties that underwent renovations between sales, typically including the addition of bedrooms and bathrooms. Frequently the commercially provided sales data made use of the bed/bath/car space numbers of the most recent sale and back filled its pervious sales with these numbers. This results in errors and a loss of information. For those properties that had lodged planning applications after 2004 (when online records began) it was possible to check via this site the numbers of bed/bath/car spaces prior to and post renovations.
- The Home Price Guide provided an additional source to check for bed/bath/car spaces numbers if they were not provided in the purchased dataset (APM 2010).
- The realesatate.com website provided an additional source to check the more recent property sales information (those that occurred in the last 2 years).

- Google Earth's Historical Imagery feature provides a series of aerial images from around 2001 onwards. This feature assisted greatly in establishing an improved approximation of a build year (house age) for newer properties, frequently enabling the viewing of when a block changed from vacant to a dwelling within the time frame of a year.
- Google Street View proved to be a key source of additional information for the number of levels of the structure, the building and roof material, as well as identifying an era of when the house was build to establish a proxy of house age/build year when this information was not available through other sources. This site also provided an additional source to check available car parking.

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