Housing Price Response to the Interaction of Positive Coastal Amenities and Negative Flood Risks

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I. Introduction

Since 1968 homeowners' flood insurance in the United States has been mainly provided through the federally-run National Flood Insurance Program (NFIP), which as of 2013 had 5.55 million NFIP policies-in-force nationwide with a total of $1.28 trillion of insured coverage (FEMA, 2013). In 2012, Congress passed the Biggert-Waters Flood Insurance Reform Act (BW-12) in order to address a number of the well-documented structural and fiscal issues of the program, including key provisions of the bill that would increase existing discounted premiums to full-risk levels. However, BW-12 was itself reformed in March 2014 with the passage of Homeowner Flood Insurance Affordability Act (HFIAA-14) that importantly curbed many of the planned BW-12 rate increases. Realtors, homebuilders, and lenders had provided steep opposition to BW-12 (WSJ, 2013) decrying the movement toward risk-based premiums as causing "property values to steeply decline and made many homes unsellable, hurting the real estate market" (Insurance Journal, March 2014). In this paper we aim to shed some further light on this depressed property value assertion through a hedonic property analysis that accounts for the potential negative housing price effects of higher flood risk (and thus higher risk-based flood insurance rates), as well as the potential positive housing price effects of living close to the water, acting together on housing sales prices in a coastal community in Texas.

There is a fair amount of existing literature on the hedonic pricing of flood risk that does support this diminished property value view, where findings from a number of studies indicate that the properties within a designated higher flood risk zone sell for a lower price than an equivalent property outside of it, typically on the order of 4 to 12 percent (Bin and Polasky 2004; Bin, Kruse and Landry 2008; Kousky 2010; Posey and Rogers, 2010; Bin and Landry 2012). This negative flood risk amenity price differential is typically attributed to higher flood insurance rates (discounted sum of future flood insurance payments) being capitalized into housing sales prices (Bin, Kruse and Landry 2008; Bin and Landry 2012).[1] However, an estimated hedonic price discount for being located in a higher flood risk zone does not always hold (USACE, 1998; Bin and Kruse, 2006; Morgan, 2007; Daniel et al., 2009). For example, Daniel et al. (2009) in their meta-analysis of 19 studies and 117 point estimates of the implicit price for location in the flood plain find that the hedonic flood zone price differentials vary considerably, anywhere from -52% to +58%.

The hedonic literature's inconclusiveness concerning a home price discount stemming from a negative flood risk amenity can be partially attributed to the tendency to capture flood risk in the empirical analysis through the use of an indicator dummy variable where 1= location within the high risk floodplain such as whether a property lies in the 100 or 500 year return periods, and 0 = location outside of it (Bin and Polasky 2004; Bin and Kruse 2006; Morgan, 2007; Bin, Kruse and Landry 2008; Kousky 2010; Posey and Rogers, 2010; Bin and Landry 2012; Atreya et al., 2013).[2] This dummy indicator structure implies that the flood risk hedonic price discount is constant across the floodplain (USACE, 1998) despite the fact that the flood risk clearly is not. For example, within an identified 100-year flood zone the flood risk can vary from a 10 year return period (10% probability of occurrence in any given year) to a 100 year return period (1%

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[1] Bin and Landry (2012) note that the sales price discount is often larger than the capitalized value of the insurance premiums, suggesting an incremental option value related to the non-insurable costs of flooding.

[2] Homeowners' lack of awareness about the flood risk classification is another concerns that could lead to an inconclusive effect (Chivers and Flores, 2002; Bin and Landry 2012). In our case, however, lack of awareness about the flood risk is less likely since Texas is only behind Florida in terms of the total number of NFIP policies-in-force with approximately 12 percent of the total NFIP portfolio. Particularly in Galveston County there are over 60,000 NFIP policies-in-force with over $13 billion in insured exposure which is the second largest flood insurance market in Texas after Harris County (Czajkowski et al, 2013).

probability of occurrence in any given year). As such, one would expect that the "hedonic price discount for floodplain location should increase with increasing flood hazard" (USACE, 1998). In fact, Czajkowski et al., (2013) and Michel-Kerjan et al. (2014) use flood catastrophe models in two Texas communities to show not only how much flood risk varies within a single NFIP designated flood risk zone, but by how much corresponding probabilistically derived localized risk-based flood insurance rates would vary as well.[3]

In order to more properly capture this inherent varying flood risk within a given flood map zone Griffith (1994) included a flood frequency (i.e., return period) variable in her analysis and found that there is a hedonic price discount only for those homes deep in the 100 year floodplain due to their higher annual probability of occurrence. A number of other studies have utilized measures of elevation or flood depth in lieu of, or in addition to, a flood risk zone indicator variable to account for the spatially inherent varying flood risk (Barnard, 1978; Tobin and Montz, 1994; Kriesel and Friedman, 2002; Zhai et al., 2003; Kousky, 2010; McKenzie and Levendis, 2010; and Atreya et al., 2013), and typically find a statistically significant relationship in the hedonic estimation. However, often the employed measure of elevation does not necessarily best convey the flood risk which would be relative to the base flood elevation, i.e., the computed elevation to which floodwater is anticipated to rise during the flood having a one percent chance of being equaled or exceeded in any given year (FEMA, 2014). For example, McKenzie and Levendis (2010) utilize elevation in relation to the mean sea-level, whereas Kousky (2010) and Atreya et al.

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[3] Furthermore, NFIP flood zones delineated from existing FEMA flood insurance rate maps (FIRMs) are known for not being as accurate as they could be to identify flood risk – many outdated due to limited mapping resources (Czajkowski et al, 2013). Thus, a dummy indicator of flood risk based upon a FEMA flood zone may convey an inaccurate flood risk in reality.

(2013) simply control for the elevation of the ground, not in relation to the base flood elevation level.

But even accounting for the inherent varying flood risk within a flood zone with a return period or elevation-based measure does not paint a complete amenity value picture as often the riskiest homes are also the most desirable in terms of their proximity to the water. Conroy and Milosch (2011) estimated the coastal premium in their study for single family homes in San Diego County and find that the coastal premium is approximately 101% for the houses within 500 feet of the coast disappearing entirely beyond around six miles. Bin et al. (2008) and Daniel et al. (2009) explicitly discuss the importance of controlling for the positive amenity values related to water proximity, and utilize distance measures of proximity to the water in their estimations.[4] Although others also control for positive amenities through distance measures (Kousky, 2010; Bin and Landry 2012; Atreya et al., 2013), an investigation of these two effects interacting jointly has rarely been employed to our knowledge.[5] And again, as homes most at risk from floods are often closest to the water and vice versa, an analysis of this interaction seems pertinent. Further, without a more granular view of flood risk within a given flood zone beyond a simple in or out location indicator, a meaningful interaction between varying flood risk and varying distance to water is likely difficult to achieve.

In this study we conduct a hedonic property analysis in Galveston County, Texas, where in addition to using flood zone indicators, we utilize data provided to us by CoreLogic that identifies the varying flood risk return periods within classified Federal Emergency Management Agency (FEMA) flood zones. Moreover we control for positive amenities associated with water

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[4] Daniel et al. (2009) find that distance is a more meaningful control for positive amenities than view.

[5] Daniel et al. (2009) and Kousky (2010) briefly discuss interaction results run as robustness check in their analyses.

proximity by using spatial analysis in Arc-GIS to calculate for each property their distance to the nearest coastline. Finally, we interact these two variables in our hedonic estimations in order to account for the potential negative effects of higher flood risk as well as the potential positive effects of living close to the water, acting together on housing sales prices in our coastal community. Our more granular view of flood risk split by return periods allows for a more meaningful interaction between the negative and positive amenities related to proximity to the water.

First we find that when using a simple flood zone indicator to represent flood risk that properties located in the riskiest aggregate 100 year flood zones command a price premium compared to those located outside. But even in this aggregate flood risk view this hedonic price premium is dependent upon the distance to the coast. For example, when using a continuous measure of coastal distance, a one percent increase in the distance from the coast is associated with a 0.07 percent decline in property price. Or, when distance is discretized in 500 feet increments those properties located within 500 feet of the coast have a premium of 36 percent as compared to only 12 percent between 500 and 1000 feet from the coast and down to 4 percent between 4000 and 5000 feet. Finally our interaction of the aggregate flood zone risk with coastal distance illustrates the importance of these two variables acting together. However, we provide a more granular view of the flood risk and distance interaction with our separate flood zone estimations utilizing the varying return period risk information inherent to each zone. In almost all cases the coefficient on the interacted variables was found to be statistically significant and typically negative. For example, with Galveston County V zone properties facing a less than 10 year return period flood risk we find that the significant 101 percent hedonic price premium for a property directly on the coast actually transitions into a hedonic price discount once distance from the coast is 2700 feet away. Thus some properties in the V zone (and other zones) are “near but yet too far” from the associated coastal water positive amenities to command a price premium due to the negative flood return period risk associated with them. This more granular interacted view of flood risk and proximity is lost in the aggregate flood zone view.

The remainder of the paper proceeds as follows: section two provides an overview of the Galveston County study area as well as the details of the data utilized in our hedonic analysis; section three lays out the methods we employ while the corresponding results are presented in section four; and finally section five concludes.

II. Study Area and Data

We focus our study in Galveston County, Texas exposed to both riverine and storm-surge flooding. Property transaction data for single family homes in Galveston County was provided by Core-Logic. After cleaning the dataset[6] we retained 35,586 property sales for our analysis between the years 2001 and 2010 since this period represented more than 99% of the sales in our data.[7] Figure 1 illustrates the location of these sales by our aggregated FEMA designated flood zones V, A, X/500, and X.[8]

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[6] We dropped the properties that did not have values for important variables such as sales price. We dropped the properties for which the sales price was less than $4000.

[7] We include the most recent sales in our analysis

[8] See appendix for our aggregated FEMA flood zone designations

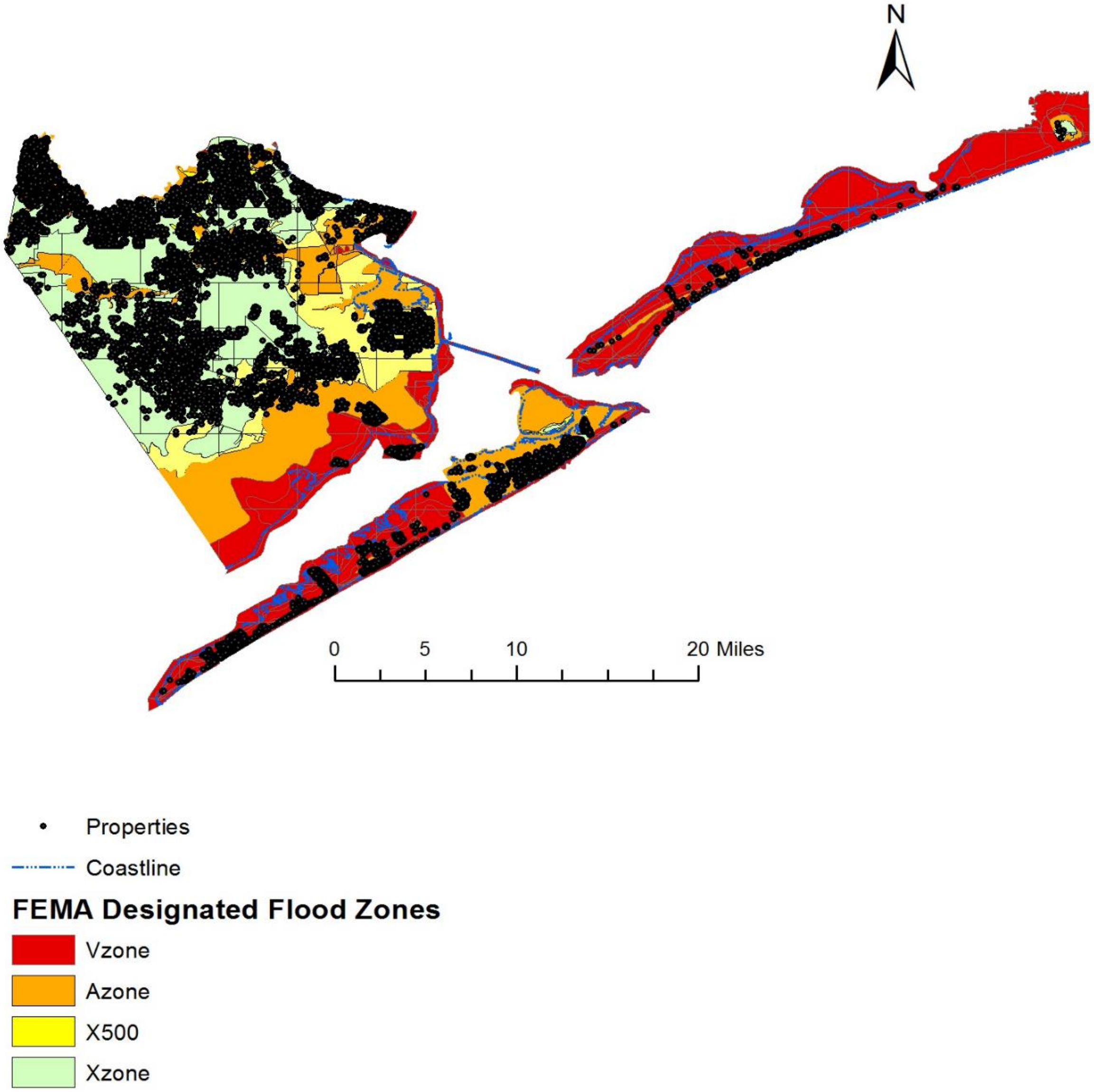

Figure 1: Housing Units and associated Flood Zones in Galveston County, Texas

While the number of sales in any one year is largest in the X/C zone, i.e., minimal flood risk areas, on average there were 381 sales per year in the high risk flood areas (V and A zones) and 627 home sales per year in the moderate flood risk area (X500/B) during this timeframe (Figure 2). We adjusted all sales prices to 2010 values utilizing the housing price index for Houston–The Woodlands-Sugar Land, Texas metropolitan statistical area from the office of

Federal Housing Finance Agency (FHFA, 2014). In a coastal community such as Galveston, an important amenity measure that affects the property price is proximity to nearest coastline (Bin et al., 2008; Daniel et al. 2009). Using spatial analysis in Arc-GIS we calculated for each property their Euclidean distance to the nearest coastline. As would be expected given their relative proximity to the coastal waterfront as shown in Figure 1 above, homes in the V and A zones sell for more on average after accounting for the size of the home with sales prices per square foot of $198.51, $115.92, $86.72, and $92.75 for the V, A, X500/B, and X/C zones respectively.

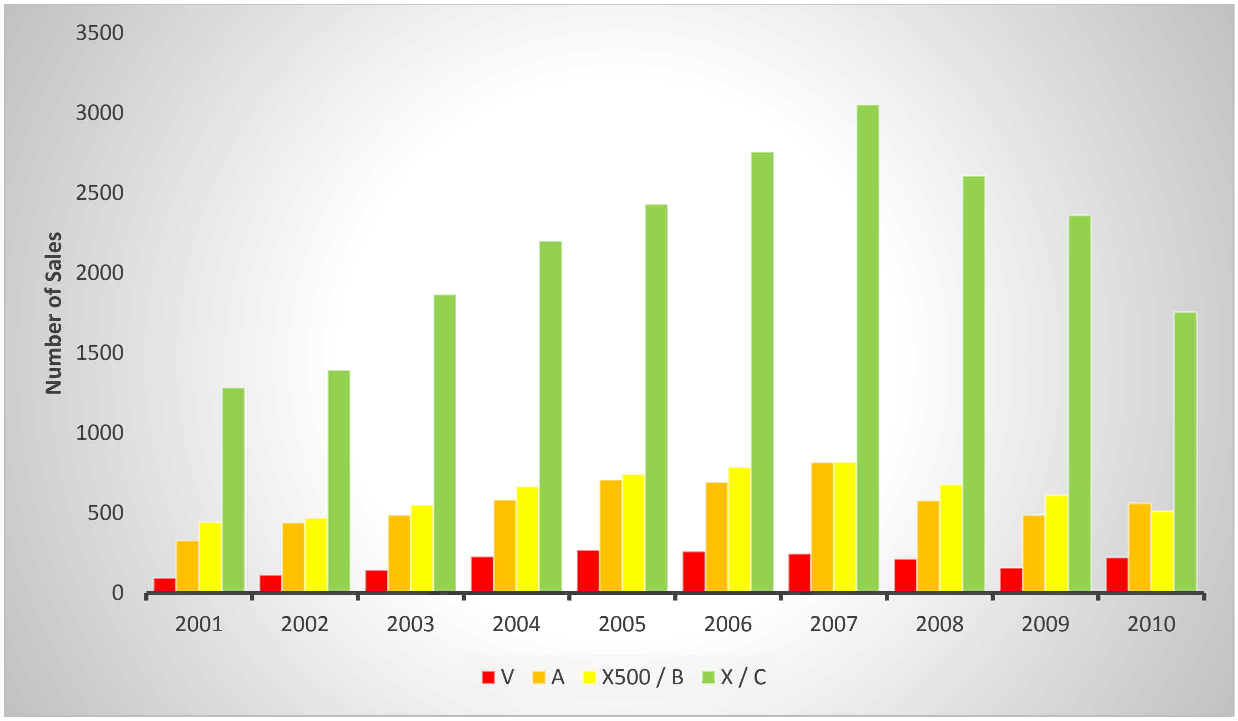

Figure 2: Number of sales by flood zones over our study period (2001-2010)

However, while homes located in V and A zones are in the aggregate relatively closer to the water as compared to those located in X/500 and X zones (98 and 66 percent of V and A zone homes sales are within 1500 meters, or approximately 1 mile, of the nearest coastline as compared to 31 and 3 percent of X/500 and X zone home sales), not every home within each zone is equal-distance to the nearest coastline. Figure 3 provides the average sales price per square foot split by distance to the nearest coastline in 500 meter increments overlaid with an A zone linear trendline. From this view of our sales price data not only do we see the varying distances to the coast within each flood zone but we also see that as distance from the nearest coastline increases, sales price per square foot generally declines within each flood zone.

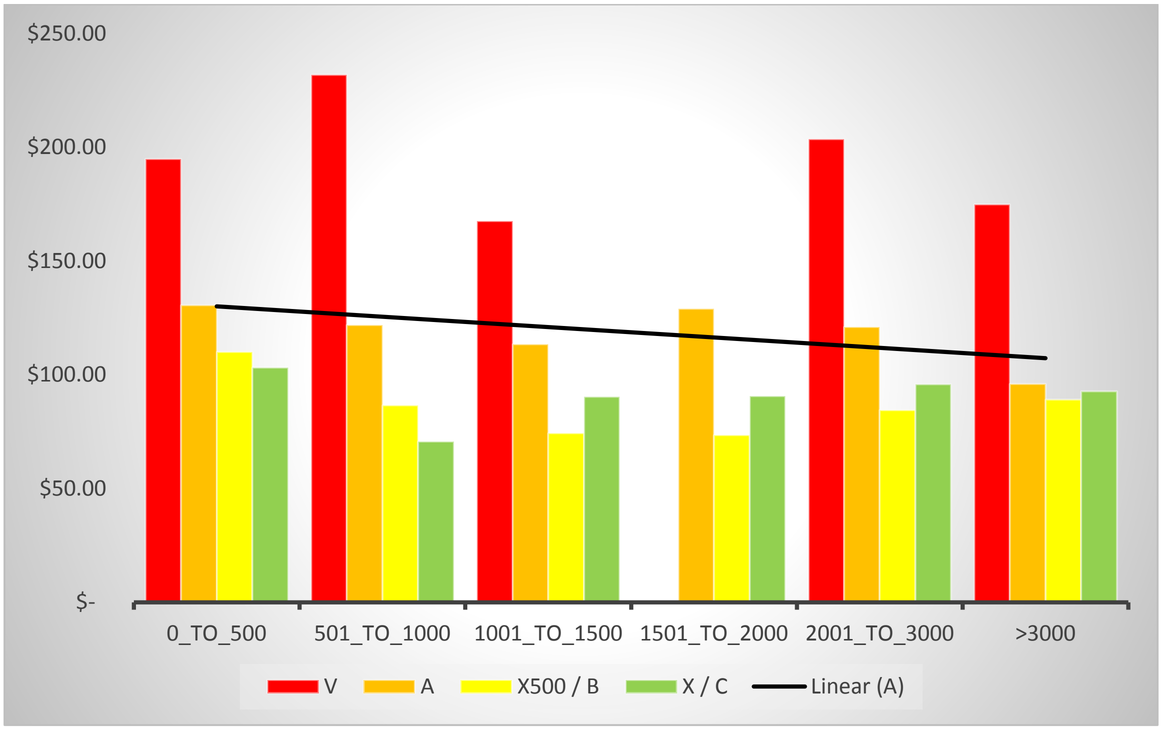

Figure 3: Property Sale Price (per sq. foot) in Flood Zones over various Distance Bands.

Furthermore, not only does the distance to the coastline vary within a flood zone, i.e., the positive amenity value, but so does the negative amenity flood risk value vary within an aggregated zone. CoreLogic determines the associated relative flood risk (i.e., flood return periods) for each home based upon a proprietary scoring of a property's elevation variance (EV) and distance to the most immediate water flood hazard. Where EV is the difference between the elevation of the ground upon which the immediate structure rests and the elevation of the flood plain that presents the greatest flood risk such asthe base flood elevation for homes in the A zone. The specific discretized flood return periods (RPs) determined by CoreLogic that we use for our hedonic analysis are: RP ≤ 10; 10 < RP ≤ 25; 25 < RP ≤ 50; 50 < RP ≤ 100; 100 < RP ≤ 250; 250 < RP ≤ 500; 500 < RP ≤ 1000; 1000 < RP ≤ 5000; and RP > 5000.

As an example of just how much the return periods can vary within a flood zone, figure 4 illustrates the distribution of the home sales over the return periods within A zone in Galveston County. While all of these homes are located within the 100 year flood plain equating to a 1 percent annual chance flood event, some of these homes are clearly at a higher risk of flooding based upon their individual location within the zone. For example, homes subject to at least a 10% chance of a flood event, or a 10 year return period comprise 14% of the sales. Nearly 80% of the sales are at a 50 year return period or less. The V, X500 and X zones (not depicted) have similar varying flood risk distributions.

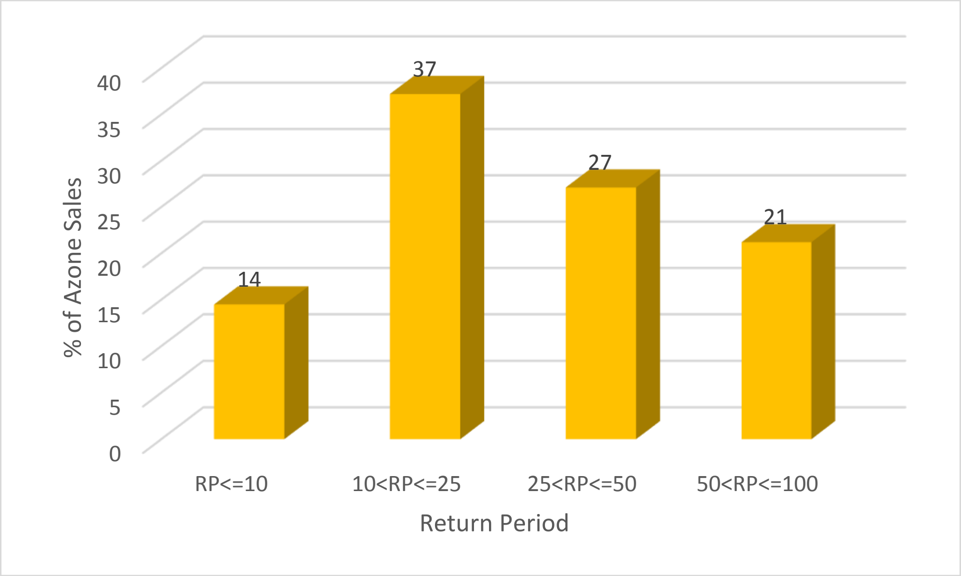

Figure 4: Percent of Property sales in various return periods within Azone

We present in figure 5 sales price per square foot by a combined view of return periods and distance to the coast. Clearly there is a variation in price per square foot depending upon the interaction of flood risk (return period) and distance to the coast. And it is precisely this interaction we will isolate in our hedonic framework.

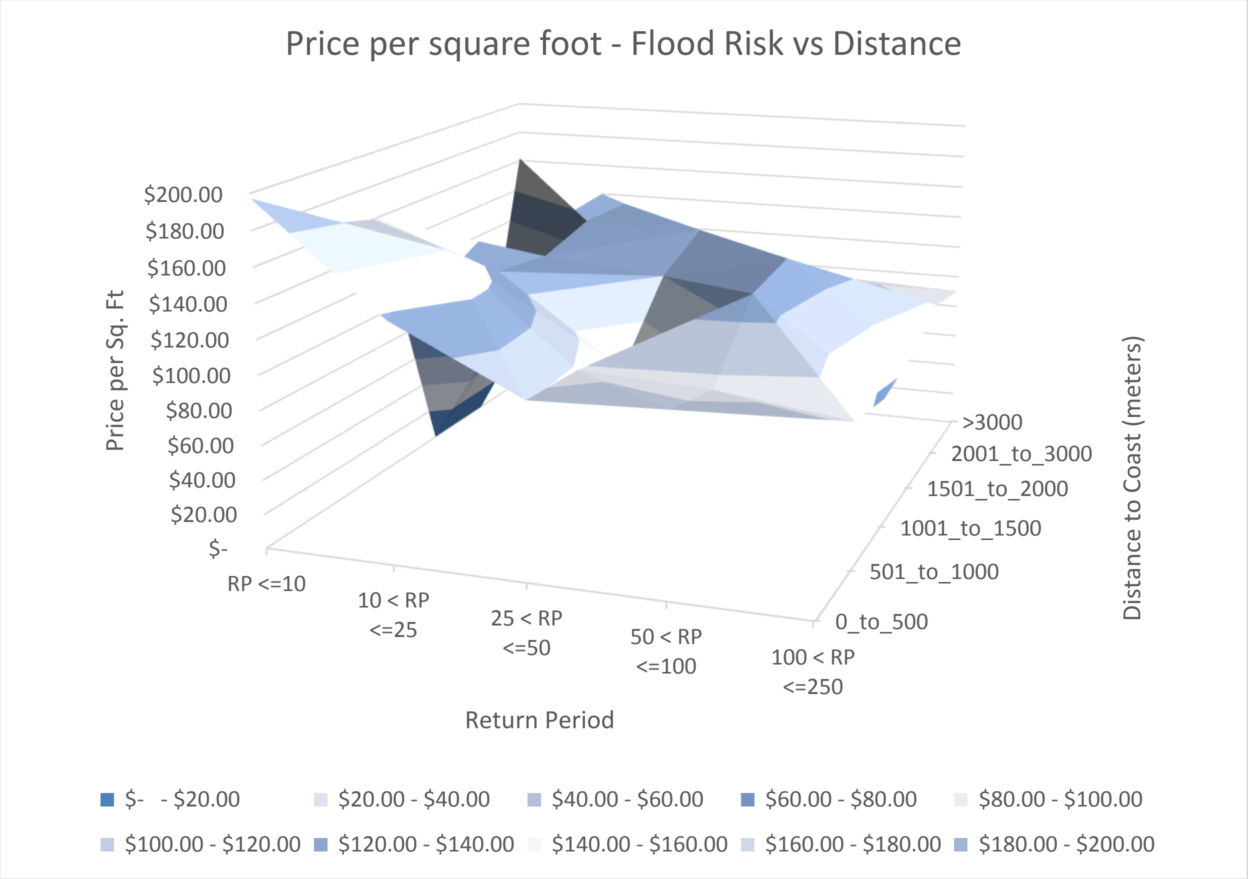

Figure 5: Price per square foot by return periods and distance to the coast

Other than square footage of the home, flood risk return period, and distance from the coast there are a number of other relevant housing attributes – structural, location/neighborhood, etc - that likely would impact sales prices and we include these in our hedonic framework. Specifically we include the following structural attributes in the estimated hedonic price functions: land square footage, building square footage, the number of stories, exterior wall type with brick = 1 and 0 =

otherwise (*aluminum, asbestos, brick veneer, brick/wood, concrete, concrete block, frame wood, metal, stone, stucco, tilt-up, wood frame*) type of foundation with slab-on-grade = 1 and 0 = otherwise (*wood, concrete, concrete block, pier, pipe/iron*) , a dummy indicator variable for the condition of the home with 1 = excellent and 0 = otherwise (*Poor, Average, Fair, Good, Very Good*) and age of the property at the time of sale. In addition to the distance to the coast we also use spatial analysis in Arc-GIS to calculate for each property their Euclidean distance to the nearest park, bus route, railroad and school. The demographic characteristics, such as the median household income and the percent of nonwhite population was determined at the census tract level using 2000 census data. As properties that are built after a community joins the NFIP require the lowest floor of the residential building to be elevated above the base flood elevation, we include a dummy variable, NFIP=1 if the property was built after 1974 (i.e. after the communities in Galveston County joined NFIP) and 0 otherwise. Finally, we include another dummy variable seawall=1 if the properties were protected by the Galveston seawall and 0 otherwise.

Table 1 provides the summary statistics of the variables used in the analysis. The average selling price in our sample is $181,690 with a typical home about 20 years old and 2,150 square feet. About 5.5 percent of the homes sold are located in Vzone and 16 percent of the homes sold are located in Azone. 6 percent of the homes sold are located in the flood return period less than 10 years. On average the distance to coast is 25,694 feet and 2.4 percent of the houses are located within 500 feet of the coast. 82 percent of the houses in our sample were built after the community joined NFIP and 11 percent of the houses are protected by seawall. As illustrated earlier, there is much variation in the price of the properties within the FEMA designated flood zones and the price variation also depends on the proximity to the coast. We further split the flood zone and return period by mean price as well as mean coastal distance at the end of Table 1. We also present the average price of the properties split by their distance to the coast.

Table 1: Description and the Summary Statistics of the Variables

Variables	Descriptions	Mean	Std. Dev.
Price (2010$)	Sale price in 2010 constant dollars	$181,690	$386,341
Flood Zones			
vzone	1 if in v zone, else 0	0.055	0.227
azone	1 if in a zone, else 0	0.159	0.366
x500	1 if in x500 zone, else 0	0.176	0.381
x	Control group (dropped in analysis)	0.610	0.488
Return Periods			
$RP \leq 10$	Return Period-less than 10 year	0.062	0.241
$10 < RP \leq 25$	Return Period-greater than 10 and less than 25 years	0.061	0.240
$25 < RP \leq 50$	Return Period-greater than 25 and less than 50 years	0.036	0.187
$50 < RP \leq 100$	Return Period-greater than 50 and less than 100 years	0.054	0.227
$100 < RP \leq 250$	Return Period-greater than 100 and less than 250 years	0.388	0.487
$250 < RP \leq 500$	Return Period-greater than 250 and less than 500 years	0.152	0.359
$500 < RP \leq 1000$	Return Period-greater than 500 and less than 1000 years	0.073	0.260
$1000 < RP \leq 5000$	Return Period-greater than 1000 and less than 5000 years	0.040	0.196
$RP > 5000$	Return Period-greater than 5000 years	0.133	0.339
Structural			
land_sf	Total area of land in sqfeet	22620	1590572
bldsf	Total area of building in sqfeet	2150	925
stories_	Total number of Stories	1	0.5
EWall_BRV	Exterior Wall (Brick=1)	0.617	0.486
Foun_SLB	Type of Foundation (Slab=1)	0.763	0.425
Cond_Exl	Condition (Excellent=1)	0.374	0.484
age	Age of the Property	20	18
Location (feet)			
busroute_d	Distance to nearest bus route	15901	14284
psclh_dist	Distance to nearest school	7886	14121
railrd_dis	Distance to nearest railroad	12769	12134
park_dist	Distance to nearest park	3225	5024
coastal_di	Distance to nearest Coastline	25694	20123

feet_W500	1 if within 500 feet of coast	0.024	0.154
feet_W1000	1 if 500 to 1000 feet of coast	0.038	0.191
feet_W2000	1 if 1000 to 2000 feet of coast	0.064	0.246
feet_W3000	1 if 2000 to 3000 feet of coast	0.046	0.209
feet_W4000	1 if 3000 to 4000 feet of coast	0.032	0.175
feet_W5000	1 if 4000 to 5000 feet of coast	0.031	0.175
Demographic			
blacknum	Number of Blacks	346	482
mh_inc	Median Household Income	78176	29474
Additional Controls			
NFIP	1 if built after community joined NFIP (after 1974)	0.821	0.383
seawall	1 if protected by seawall	0.110	0.313

Flood Zones	**Mean Price**	**Mean Distance to Coast (feet)**	**Number of Sales**
vzone	312,874	1,136.48	1,942
azone	172,305	10,989.34	5,670
x500	144,044	14,922.77	6,272
x	183,282	34,845.81	21,702
Return Periods			
RP ≤ 10	287,540	1,260	2,204
10 < RP ≤ 25	190,176	2,911	2,179
25 < RP ≤ 50	137,182	4,621	1,288
50 < RP ≤ 100	185,377	25,462	1,939
100 < RP ≤ 250	158,727	27,636	13,811
250 < RP ≤ 500	168,784	33,182	5,394
500 < RP ≤ 1000	212,236	41,875	2,604
1000 < RP ≤ 5000	181,427	41,848	1,427
Coastal Distance			
feet_W500	305,199	-	862
feet_W1000	217,974	-	1,350
feet_W2000	180,965	-	2,294
feet_W3000	150,466	-	1,623
feet_W4000	143,677	-	1,132
feet_W5000	134,511	-	1,120

III. Methods

Hedonic models (Rosen 1974; Freeman 2003) have been extensively used in the past to partition out the value of an environmental amenity or disamenity using the actual property transaction data based on the intuitive notion that the component values of various attributes of heterogeneous goods are reflected in price differentials. In a hedonic model, price of the property (**P**) is modeled as a function of its structural attributes (**S**) such as building square feet, age, number of bathrooms; location attributes (**L**) such as distance to coast, distance to park; and the environmental variable of interest which in our case is flood risk as depicted by FEMA's flood insurance rate maps and an alternative measure of flood risk provided by varying flood return periods (R). The basic hedonic model specification takes the following form:

$$\log(\mathbf{P}_{it}) = \beta_o + \beta_1' \mathbf{S}_{it} + \beta_2' \mathbf{L}_i + \beta_3 R_i + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

In equation 1, subscript *i* and *t* represent property and time respectively. γ_i and δ_t are zip code and time fixed effects respectively. The first order differentiation of price, (**P**), with respect to the housing attributes provide the marginal implicit price which can be interpreted as the marginal willingness to pay for additional unit of that attribute.

As we adjusted all sales prices to 2010 values utilizing the FHFA housing price index for Houston–The Woodlands-Sugar Land, TX MSA, we utilize this index to identify the fixed effect time segmentations in our data (δ_t). Specifically we apply a segmented regression methodology to the quarterly Houston–The Woodlands-Sugar Land FHFA HPI values from 2001 to 2010 in order to identify the unknown structural breakpoints in time for this housing market. Segmented or piecewise regression allows the detection of single or multiple change points at unknown points in time given initial guess values from the user (Muggeo 2003). We detect five change points in the HPI data as illustrated in the appendix: 1) 2001 between the 2nd and 3rd quarters; 2) 2004, between the 3rd quarter and the 1st quarter of 2005; 3) 2007 between the 2nd and 3rd quarters; 4) 2009 between the 1st and 2nd quarters; and 5) 2009 between the 3rd quarter and the 1st quarter of 2010. Given these identified housing market breakpoints we account for their potential time effect in our estimations by creating time interval dummy variables (δ_t) to represent each of them.[9]

One of the econometric concerns in using a hedonic model is the presence of spatial dependence among neighboring properties. Spatial dependence in property values can arise due to neighboring properties sharing common features such as similar location amenities, similar structural attributes due to common timing of construction. Although recent critiques by McMillen (2010), Pinske and Slade (2010) and Gibbons and Overman (2012) suggest that spatial models do not provide a valid approach to causal identification, the use of spatial hedonic models is appropriate since ignoring the spatial dependence in a hedonic analysis lead to an inefficient or even inconsistent estimates (Anselin and Bera, 1998).

For our analysis, we use a spatial hedonic model allowing for spatial interactions in the dependent variable and the disturbances. More formally, a spatial autoregressive model with autoregressive disturbance (SARAR) is employed following Anselin, (1988) and Kelejian and Prucha (2010). The SARAR model can be written as:

$$\log(\mathbf{P}_{it}) = \beta_o + \lambda \mathbf{W} \ln(P_{jt}) + \beta_1' \mathbf{S}_{it} + \beta_2' \mathbf{L}_i + \beta_3 R_i + \gamma_i + \delta_t + \varepsilon_{it} \tag{2}$$

Where,

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[9] We employ this segmented regression methodology over the typically employed yearly fixed effects to account for the national housing market boom and bust that occurred in the U.S. during this timeframe (Boyle et al., 2012), although not as pronounced in Texas. We did additionally run yearly fixed effect models with qualitatively similar results.

$\varepsilon_{it} = \rho \mathbf{M} \varepsilon_{jt} + \mu_{it}$; μ_{it} is i.id (assumed to be independent and identically distributed)

The spatial weights matrix W and M (W=M) are taken to be known and stochastic. The lambda (λ) and rho (ρ) are the spatial lag parameter and spatial autocorrelation coefficient respectively.

In spatial models, one of the challenges lies in defining an exogenous weights matrix (W) that captures the relationship between the spatial units. In general, there is no consensus on appropriate spatial weights matrix (Anselin, 1988). Queen Contiguity matrix and inverse distance matrix are the most commonly used matrices in spatial models. Queen Contiguity matrix is structured so that if the i^{th} and j^{th} properties share a common border or vertex, the elements of the spatial weights matrix W_{ij} get a value of 1, 0 otherwise. The inverse distance matrix is structured in such a way that the elements of the spatial weights matrix W_{ij} get a value equal to inverse of Euclidian distance between the i^{th} and j^{th} properties. In our case we use a hybrid matrix combining the queen contiguity and inverse distance matrix where distance decay was allowed in the queen contiguity matrix. The hybrid matrix was min-max normalized.[10] We employ a generalized spatial two-stage least square (GS2SLS) estimator.[11]

Use of FEMA designated flood risk zones

First, to incorporate flood risk in our hedonic analysis we used traditional FEMA designated flood hazard zones: the Vzone, Azone and the X500 zone. Thus, the hedonic model[12] is as follows:

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[10] A min-max normalization preserves symmetry and the basic model specification (Drukker et. al 2011)

[11] A GS2SLS estimator produces consistent estimates and does not depend on the assumption of normality (Arraiz et al, 2010). Maximum likelihood estimation procedure which is an alternative to GS2SLS depends on the assumption of normality which in our case is not appropriate since the residuals in our case are not normally distributed.

[12] Due to large dataset employed in the analysis, we were unable to run a spatial model. However, later we show that the results from the SARAR models are robust to OLS model.

$$\log(\mathbf{P}_{it}) = \beta_o + \beta_1'\mathbf{S}_{it} + \beta_2'\mathbf{L}_i + \beta_3 vzone_i + \beta_4 azone_i + \beta_5 X500_i + \gamma_i + \delta_t + \varepsilon_{it} \quad (3)$$

The variable Vzone is a dummy equal to 1 if the property falls within the designated Vzone and 0 otherwise. Similarly, the variable Azone is a dummy equal to 1 if the property falls within the designated Azone and 0 otherwise. The Azone and Vzone, both fall under the 100 year return period while Vzone is also subject to storm surge. The X500 variable in the model is a dummy equal to 1 if the property falls within the designated X500 zone and 0 otherwise. The properties that fall in X zone are the control groups in equation (3).

Distance to coast is an important factor that affects the price of a property. As mentioned earlier, Conroy and Milosch (2011) find a significant coastal premium for houses within 500 feet of the coast. We estimate three variations of equation (3) where first we include the natural log of distance from the coast to capture the diminishing marginal returns for the proximity as distance increases. The estimate from the natural log of coastal distance is an average premium effect measured at the mean. We also construct distance dummy variables to capture discrete distance effects, i.e., within 500 feet, between 500 and 1000 feet, between 1000 and 2000 feet and so on. Lastly we interact the continuous natural log of distance to coast variable with the flood zones to account for the positive and negative amenity variables acting together on housing values.

Use of flood risk return periods within the FEMA designated flood risk zones

In order to account for the inherent variation in the flood risk within any designated flood zone we include the return periods in our hedonic estimation. We note that according to the CoreLogic data there are more than 13,000 properties within the Galveston County Xzone that have a return period less than 500 years when in theory zone X is the area determined to be outside the 500 year flood. This discrepancy is probably due to FEMA flood hazard maps not always being completely in sync with the actual flood return period (Czajkowski et al. 2013). However, for other zones (Vzone /Azone /x500) the return periods are comparable.

The FEMA designated V zone properties fall under either a flood return period less than or equal to 10 years or a return period greater than 10 and less than or equal to 25 years. The SARAR model we use for the Vzone properties is as follows:

$$\log(\mathbf{P}_{it}) = \beta_o + \lambda \mathbf{W} \log(P_{jt}) + \beta_1' \mathbf{S}_{it} + \beta_2' \mathbf{L}_i + \beta_3 rp\_lessthan10_i + \delta_t + \gamma_i + \rho \mathbf{M} \varepsilon_{ij} + \mu_{it} \quad (4)$$

The variable *rp_lessthan10* in equation (4) is a dummy equal to 1 if the property falls within a return period less than or equal to 10 years. The control group in this equation are the properties that fall within the return period greater than 10 years and less than or equal to 25 years (10<RP<=25).

For the Azone we use the following specification:

$$\log(\mathbf{P}_{it}) = \beta_o + \lambda \mathbf{W} \log(P_{jt}) + \beta_1' \mathbf{S}_{it} + \beta_2' \mathbf{L}_i + \beta_3 rp\_lessthan10_i + \beta_4 rp\_10to25 + \beta_5 rp\_25to50$$
$$+ \gamma_i + \delta_t + \rho \mathbf{M} \varepsilon_{jt} + \mu_{it}$$

(5)

In equation (5), the control group is the properties that fall within the return period greater than 50 years and less or equal to 100 years.

The SARAR model for X500 zone is as follows where the control group are the properties that fall in the return period greater than 250 years and less than or equal to 500 years.

$$\log(\mathbf{P}_{it}) = \beta_o + \lambda \mathbf{W} \log(P_{jt}) + \beta_1' \mathbf{S}_{it} + \beta_2' \mathbf{L}_i + \beta_3 rp\_100to250 + \gamma_i + \delta_t + \rho \mathbf{M} \varepsilon_{jt} + \mu_{it} \quad (6)$$

Finally, for Xzone the SARAR model used was as follows:

$$\log(\mathbf{P}_{it}) = \beta_o + \lambda W \log(P_{jt}) + \beta_1{}' \mathbf{S}_{it} + \beta_2{}' \mathbf{L}_i + \beta_3 rp\_100to250_i + \beta_4 rp\_250to500 + \beta_5 rp\_500to1k$$
$$+ \beta_6 rp\_1kto5k + \gamma_i + \delta_t + \rho M \varepsilon_{jt} + \mu_{it}$$

(7)

In equation (7), the control group are the properties that fall within the return period greater than 5000 years. As with FEMA flood risk zone model equation (3), we run three variations of equations (4), (5), (6), and (7) with: i) natural log of distance to the coast; ii) distance dummy variables; and iii) the return periods interacted with the natural log of distance to the coast.

IV. Results

Table 2 presents the estimation results of OLS regression using the FEMA flood zone classifications of V, A, and X500 zones as in equation 3, with the low risk Xzone as the control group. We estimate three different models as discussed in the methods section where model (1) includes the log of coastal distance; in model (2), we control for distance to coast using coastal distance dummies with 500 to 1000 feet increments for distance within a mile; and in model (3), we interacted the flood zones with the log of coastal distance.

Across all the models, we find that the properties located in high-risk areas such as V and A zones command a price premium (statistically significant at the 1 percent level in all three models) suggesting that the associated positive amenity values of living in the 100 year flood zone (V and A zone) in Galveston county outweigh the negative flood risk. This result is similar to other coastal community estimates as shown by Bin and Kruse (2006) and Daniel et al. (2009), where the positive amenity impacts of a coastal community has a strong effect. The price premium for V zone properties is 40.91% and 40.07% in model 1 and 2 respectively[13] which means that a

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[13] The marginal effect of a dummy variable is calculated as: [exp (β)-1]*100 (Halvorsen and Palmquist 1980).

property in V zone sells for $74,311 and $72,676 more than an equivalent property in the Xzone (the control group) when evaluated at an average priced home ($181,690). The variable *ln_coast* is negative and statistically significant in model 1, implying that proximity to coast is highly desirable and increasing distance from the coast has strong negative impact on the property prices.[14] To put this in perspective, for an average priced home ($181,690), moving away from the coastline 25,694 feet (average distance) results in a decrease in property values by $12,718 (7%). In model 2, we find that there is a monotonic decline in coastal premium, from a 36% premium for properties located within 500 feet, to 12% for those between 500 feet and 1000 feet, to 7.6% for those between 1000 and 2000 going down to 3.9% for those between 4000 and 5000 feet.

From model 1 and 2 (i.e. by just controlling for the distance to coast) we clearly see a decay in premium for an average property that is an average distance away from the coast. We interact the negative amenity flood zone risk variable with the positive amenity variable (the proximity to coast) to obtain a more granular view of the decay with these two variables acting together jointly. In model 3, therefore, we interact the flood zone with the log of coastal distance and find a marked increase in the price premium for the V zone properties of almost 146% , which is equivalent to $266,537 when evaluated at an average priced home (Figure 6).[15] However, note that this high premium is for the properties in the V zone that are right on the coast and the premium decays at the rate of 7.8% as the distance from the coast increases as suggested by negative and significant *coastdxVzone* interaction. For example, the premium decreases to almost 72.09% from 146% in V zone as the distance from the coast increases to 100 feet which is equivalent to a decrease of

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[14] We interpret log-log coefficient as elasticities

[15] The premium is calculated as (exp(0.903)-1)*100=146%. Note that the calculated premiums is - as compared to the control group (in this case the X zone properties).

$130,989 when calculated for average priced home.[16] Similarly, compared to X zone properties the A zone properties also command a price premium equivalent to 8.12% and 9.6% in model 1 and 2 respectively and a higher premium of 28% for the A zone properties that are right on the coast (model 3). We also find that the premium decays (negative and significant *coastdxAzone* interaction) at a rate of 1.8% as the distance to coast increases for A zone properties. The results illustrate the importance of accounting for these values interacting jointly on housing prices. Regarding the structural variables, all the coefficient are significant at one percent level and have expected signs except for variable *stories* which is insignificant. As per the location variables, coefficient estimates indicate that being farther from a bus route or park decreases property prices, whereas being nearby a school or railroad increases property prices. The median household income have an expected positive sign. The *NFIP* dummy is positive and significant suggesting that the properties that are built after the communities joined NFIP in Galveston County are worth more, ceteris paribus. Also, the properties that are protected by seawall are priced higher as suggested by positive and significant seawall dummy (*Seawall*), likely due to the sense of safety that the seawall provides in the risky zones. In all the models, we have included the time segment and the zip code fixed effects.

Table 2: Regression Results using the FEMA designated Flood Hazard Zones.

VARIABLES	(Model 1)	(Model 2)	(Model 3)
Vzone	0.343***	0.337***	0.903***
	(0.0241)	(0.0248)	(0.118)
Azone	0.0781***	0.0917***	0.250***
	(0.0107)	(0.0106)	(0.0675)
X500	0.00413	0.0202***	-0.0879
	(0.00773)	(0.00772)	(0.0852)

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[16] The premium for V zone properties located 100 feet away from the coast is calculated as (exp(0.903-0.0782*ln(100))-1)*100=72.09%

ln_coast	-0.0703***		-0.0575***
	(0.00436)		(0.00547)
coastdxVzone			-0.0782***
			(0.0169)
coastdxAzone			-0.0187***
			(0.00686)
coastdxX500			0.0104
			(0.00859)
Coast_W500		0.316***	
		(0.0241)	
Coast_W1000		0.129***	
		(0.0212)	
Coast_W2000		0.0741***	
		(0.0191)	
Coast_W3000		0.0701***	
		(0.0184)	
Coast_W4000		0.00292	
		(0.0195)	
Coast_W5000		0.0463***	
		(0.0177)	
land_sf	5.66e-10***	6.14e-10***	5.86e-10***
	(1.84e-10)	(1.87e-10)	(1.87e-10)
bldsf	0.000338***	0.000340***	0.000339***
	(5.12e-06)	(5.08e-06)	(5.12e-06)
stories_	0.00312	-0.00119	0.00201
	(0.00644)	(0.00641)	(0.00644)
EWall_BRV	0.0452***	0.0350***	0.0436***
	(0.00645)	(0.00640)	(0.00644)
Foun_SLB	0.150***	0.142***	0.149***
	(0.0110)	(0.0111)	(0.0110)
Cond_Exl	0.0635***	0.0637***	0.0641***
	(0.00562)	(0.00563)	(0.00563)
age	-0.00333***	-0.00306***	-0.00333***
	(0.000464)	(0.000459)	(0.000464)
age2	3.13e-05***	2.82e-05***	3.11e-05***
	(5.90e-06)	(5.83e-06)	(5.91e-06)
ln_busrout	-0.0159***	-0.0129**	-0.0136***
	(0.00497)	(0.00512)	(0.00507)
ln_schl	0.0202***	0.0363***	0.0233***
	(0.00421)	(0.00410)	(0.00421)
ln_railroa	0.0268***	0.0168***	0.0285***
	(0.00465)	(0.00455)	(0.00474)
lnpark	-0.00887***	-0.0112***	-0.00823***
	(0.00257)	(0.00256)	(0.00256)
blacknum	-2.62e-05***	-2.82e-05***	-2.59e-05***
	(6.35e-06)	(6.38e-06)	(6.35e-06)
lnInc	0.135***	0.131***	0.131***
	(0.00936)	(0.00941)	(0.00947)
NFIP	0.133***	0.142***	0.132***
	(0.0108)	(0.0108)	(0.0108)
seawall	0.0630***	0.0973***	0.0858***

	(0.0235)	(0.0236)	(0.0237)
Constant	9.350***	8.550***	9.212***
	(0.123)	(0.113)	(0.125)
Year FEs	Y	Y	Y
Zip Code FEs	Y	Y	Y
Observations	35,586	35,586	35,586
R-squared	0.595	0.594	0.596

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Accounting for varying return periods – segmented by various flood zones

As we illustrated, there is much variation in flood risk within any FEMA designated flood zones. Thus, here we use return periods in our hedonic estimations to capture the varying flood risk within each FEMA designated flood zones. We estimate separate spatial models for each aggregate flood zone where model (1) includes the log of coastal distance; model (2) uses coastal distance dummies with 500 to 1000 feet increments for distance within a mile; and model (3) interacts the flood zone specific return periods with the log of coastal distance.to account for the joint effect of the positive and negative amenity variables.

V zone

The estimates of the SARAR model for V zone properties from equation (4) are provided in Table 3 wherethe V zone flood return period varies from less than 10 years up to 25 years. In Table 3, the control group are the properties that fall within the return period greater than 10 year and less than or equal to 25 year (*10<rp<=25*) and across all the models, results show that compared to this control group, those properties that fall within a return period less than 10 years sell for a higher price (insignificant in model 2). So while these are the riskiest properties (10 percent or less annual chance of flooding) they are also the closest to the coast on average suggesting that people value coastal amenity more than the risk associated with living near the water. This result further highlights the fact that even within the V zone there are price differences based on the inherent varying flood risk within the zone. Utilizing a single flood risk zone indicator does not allow to capture such variations. From the aggregate flood risk view presented earlier (Table 2) we showed that on an average the properties in the V zone commanded a price premium, however, we were unable to partition out the price differences within the V zone properties. Utilizing the more granular return period view of flood risk we find that even within the V zone the more risky properties (located in the return period less than 10 years) are valued at a higher premium (Figure 7).

Similar to the Table 2 results, we find that the distance to coast is an important determinant of property price. The negative coefficient on the variable *ln(coast)* in model 1 suggest that in the V zone a 1% increase in the average distance from the coast is associated with a 0.196% discount in the price of the property. In model 2, we included various distance to coast dummies and find the effect to be from 52% premium for properties located within 500 feet of the coast, to 25% for those between 500 and 1,000 feet, to 11% for those between 1,000 and 2,000 feet.[17] In model 3, we interacted the coastal distance variable with the return period to capture the tradeoff between the risk and the coastal amenity. As with model 1 and 2, we find that as the distance from coast increases, the property prices in rp<=10 decreases as shown by a significant and negative interaction term between *ln(coast)* and *rp<=10.* In other words, although the most high-risk homes in the V zone appear to command a price premium, this premium decreases as the distance from

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[17] The marginal effect for coastal distance dummy is calculated as: $[\exp(\beta)-1])*1/1-\lambda$ where $1/1-\lambda$ is the spatial multiplier.

the coast increases. For the properties located in the return period less than 10 years, figure 6 shows the diminishing coastal premium as the distance to coast increases (as compared to control group). This is a more granular view of the interacted flood risk.

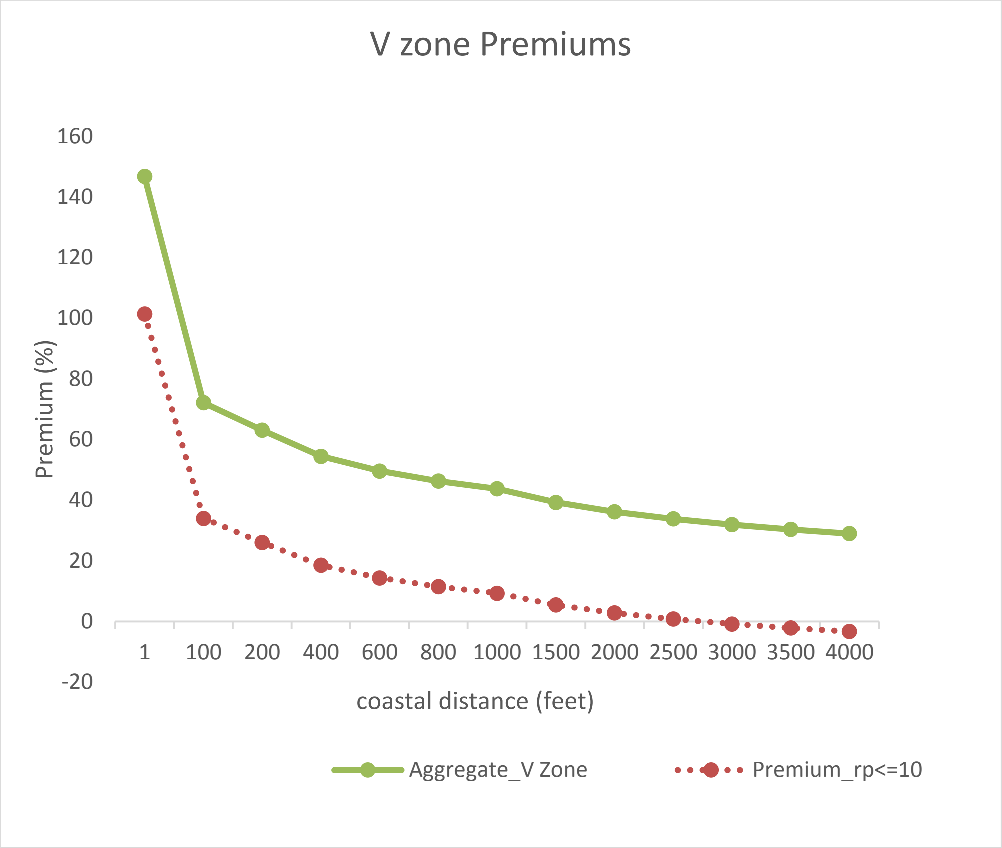

Figure 6: Comparison of V zone Premiums over various distance from coast

As shown in the figure 6, we find 101% premium for the properties that are right on the coast which declined to 71% for the properties that were 100 feet away from the coast. We find that the premium vanished for the properties that are located beyond 2700 feet.[18] Figure 6 also

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[18] These results are as compared to the V zone that are located in return period greater than 10 and less than 25. The calculations are based on model 3 results.

presents the premium decay for properties in V zone from our aggregate estimates where we do not differentiate between the return periods (Premium_Vzone). In the aggregate view, we did not see any negative premium, however, that is not the case as shown in the more granular view.

Figure 7 provides the overall picture of the V zone properties (from aggregate view as well as within zones view).

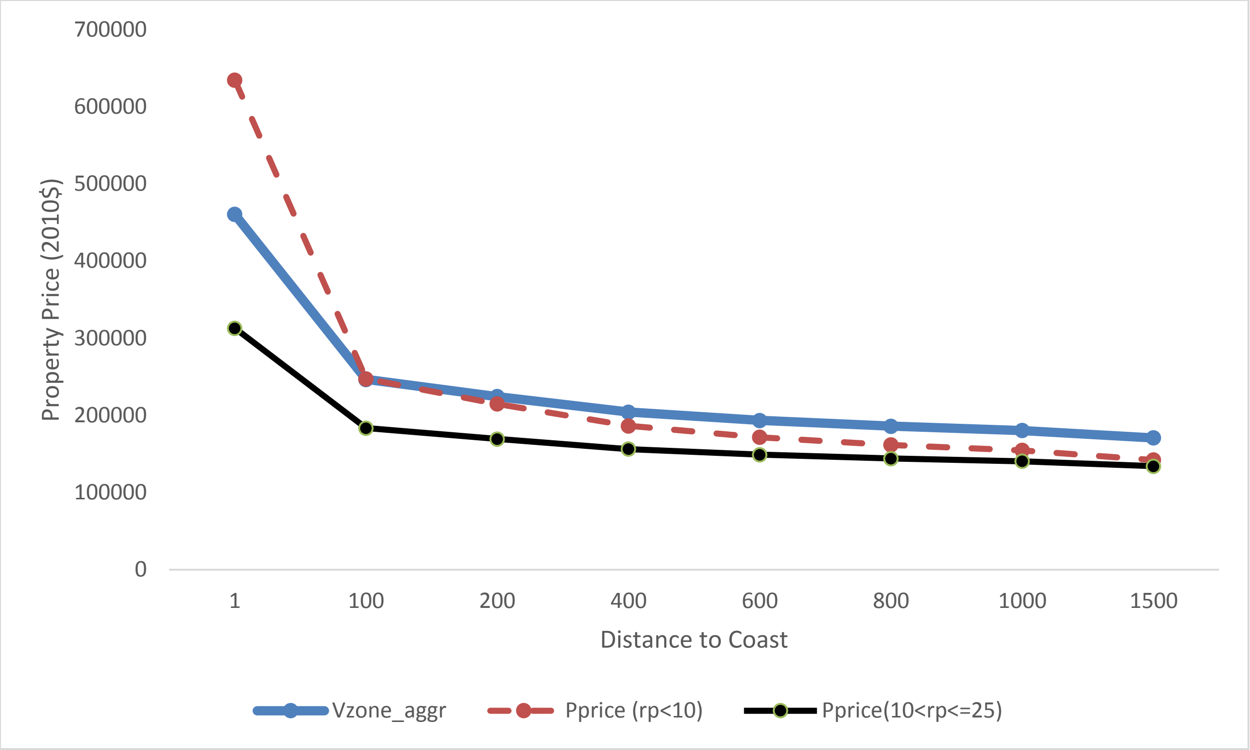

Figure 7: The Decay in the Predicted Price of a Property in V-zone

In the aggregate view we find that an average priced home when placed right on the coast would cost $460,495 which declines to $246,504 when moved 100 feet away from the coast. The rate of decay in this case was found to be approximately 13.5%. However, in a more granular view within the Vzone we find that the properties that are located in return period less than 10 years are priced much higher at $634,477. The rate of decay in this case is steep at almost 20.4% as one moves away from the coast. The properties that fall in the return period greater than 10 and less than 25 (*10<rp<=25*) is priced at $312,874 and the rate of decay is 11.6% for those properties. This result is consistent with figure 6 where we found a premium of approximately 101% for properties located in return period less than 10.

All the other variables such as structural attributes, location attributes, additional dummies (NFIP and Seawall), year fixed effects and zip code fixed effects are included in all the models[19] Regarding the spatial parameters, we find that the spatial lag parameter (λ) is not significant suggesting that there is no significant adjacency effect however, there is presence of spatial autocorrelation as suggested by a significant spatial error parameter (ρ).

Table 3: Regression Results Using varying Flood Return Period within V-zone

VARIABLES	(Model 1)	(Model 2)	(Model 3)
rp<=10	0.0875**	0.0364	0.707**
	(0.0351)	(0.0373)	(0.359)
ln(coast)	-0.196***		-0.116**
	(0.0201)		(0.0506)
ln(coast) *rp<=10			-0.0885*
			(0.0510)
Coast_W500		0.425***	
		(0.0713)	
Coast_W1000		0.238***	
		(0.0664)	
Coast_W2000		0.116*	
		(0.0639)	
Coast_W3000		0.119	
		(0.0765)	
Structural attributes	Y	Y	Y
Location Attributes	Y	Y	Y
Year & Zip code FEs	Y	Y	Y
Constant	8.869	7.112***	0
	(0)	(0.0274)	(0)
Lambda	0.00745	0.00542	0.00828
	(0.0143)	(0.0149)	(0.0144)
Rho	4.909**	4.536**	4.855**
	(2.266)	(2.276)	(2.119)

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[19] The coefficients are not presented here for brevity. Available upon request.

Observations	1,942	1,942	1,942

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

A Zone

In table 4, we present results for the varying flood risk return periods within the Galveston County Azone from equation (5). Here the flood return period varies from less than 10 years up to 100 years. The control group in this regression are the properties that fall within the flood return period greater than 50 years and less than or equal to 100 year return period (*50<rp<=100*). Consistent to results from Vzone, we find that the properties that fall in a lower return period (riskier areas) command a price premium. For instance, the premium for properties that fall in the return period 10 year or less ranges from 44% to 66% as suggested by coefficient of *rp<=10*. When evaluated at an average priced home the premium is equivalent to 97,714 to 117,257 respectively. Similarly, the price premium for the properties that are located in the flood return period greater than 10 and less than or equal to 25 is equivalent to $22,651 to $43,718 depending on the model specification.

Table 4: Regression Results Using varying Flood Return Period within A-zone

VARIABLES	(Model 1) lnprice	(Model 2) Lnprice	(Model 3) lnprice
rp<=10	0.506***	0.518***	0.637***
	(0.0482)	(0.0482)	(0.193)
10<rp<=25	0.224***	0.232***	0.0525
	(0.0332)	(0.0332)	(0.180)
25<rp<=50	0.0861***	0.0840***	0.158
	(0.0269)	(0.0272)	(0.165)
Ln(Coast)	-0.0577***		-0.0552***
	(0.0112)		(0.0159)
Ln(Coast)* rp<=10			-0.0181
			(0.0245)
Ln(Coast)*10<rp<=25			0.0225
			(0.0218)
Ln (Coast)*25<rp<=50			-0.00930
			(0.0195)

Coast_W500		0.252***	
		(0.0512)	
Coast_W1000		0.0903*	
		(0.0507)	
Coast_W2000		0.0479	
		(0.0452)	
Coast_W3000		0.0859**	
		(0.0434)	
Coast_W4000		0.0107	
		(0.0423)	
Coast_W5000		0.0996**	
		(0.0393)	
Structural attributes	Y	Y	Y
Location attributes	Y	Y	Y
Year and Zip code Fes	Y	Y	Y
Constant	9.063***	8.352***	9.005***
	(0.387)	(0.364)	(0.409)
Lambda	-0.00245	-0.00225	-0.00240
	(0.00449)	(0.00447)	(0.00447)
Rho	1.890***	1.881***	1.878***
	(0.121)	(0.118)	(0.122)
Observations	5,670	5,670	5,670

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 8 shows the predicted price of the properties located in various return periods within Azone compared to the aggregate view of the Azone. As shown in the figure, contrary to the predicted price shown by the aggregate view ($233,294 when evaluated at an average priced home for properties right on the coast) the properties in the Azone that are located in the return period less than 10 years (rp<10) right on the coast are expected to be priced higher at $325,794 which decays as the distance to coast increases. Properties that are located in higher return periods which are farther from the coast are priced lower than the ones in the most riskier area (rp<10). This is expected as these riskier homes are typically closer to the water and its associated positive amenity values. The interaction of the return period with the coastal distance in model 3, however, are not statistically significant although coefficient signs are generally negative.

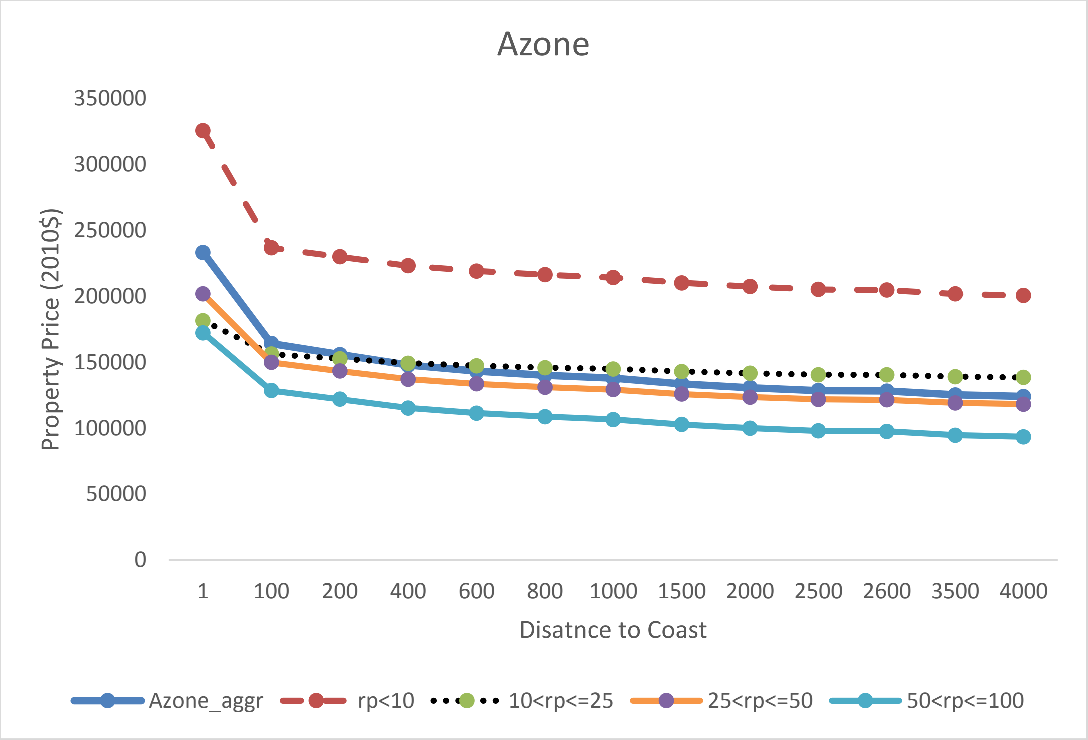

Figure 7: The Decay in the Predicted Price of a Property in A-zone

X500

The estimates for the X500 zones using varying return period within that zone from equation (6) is presented in table 5. The return period varies from 100 years to 500 years in X500 zone. Within X500 zone we did not find any significant difference between the properties that are located in the return period greater than 250 and less than or equal to 500 (250<rp<=500) and the return period greater than 100 years and less than or equal to 250 years (100<rp<=250).

Table 5: Regression Results Using varying Flood Return Period within X500 zone.

VARIABLES	Model 1	Model 2	Model 3
100<rp<=250	-0.0265	0.0103	0.302
	(0.0188)	(0.0201)	(0.239)
Ln (Coast)	-0.00246		-0.00246
	(0.0110)		(0.0387)

Ln (Coast)*100<rp<=250			-0.0330
			(0.0251)
Coast_W500		0.404***	
		(0.0860)	
Coast_W1000		-0.0984**	
		(0.0459)	
Coast_W2000		-0.0367	
		(0.0351)	
Coast_W3000		-0.0522*	
		(0.0301)	
Coast_W4000		-0.0568*	
		(0.0301)	
Coast_W5000		-0.0781**	
		(0.0304)	
Constant	8.556***	7.934***	7.434***
	(0.323)	(0.268)	(0.396)
Structural Attributes	Y	Y	Y
Location Attributes	Y	Y	Y
Year & Zipcode FEs	Y	Y	Y
Lambda	-0.00249	-0.00254	-0.00259
	(0.00271)	(0.00276)	(0.00276)
Rho	1.298***	1.341***	1.335***
	(0.158)	(0.157)	(0.159)
Observations	6,272	6,272	6,272

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

X Zone

Table 6 shows the coefficient estimates of equation 7. The flood return period in X zone varies from a return period greater than 100 to a return period less than or equal to 5000. The negative coefficient of the flood return periods across all the models indicate that compared to the control group (properties that lie within the return period greater than 5000 years), the properties that lie within the return periods greater than 100 and less than or equal to 1000 years are discounted by a 2% minimum to a 41% at maximum although insignificant in model 1. The highest significant discount of 41% is seen for the properties that lie in the return period greater than 250 and less than 500 years. However, as the distance from the coast increases we find a premium for those properties as suggested by a positive and significant _Ln (coast)*50<rp<=500_ variable. This result seems to be due the location of the property which is so near to water but yet so far that the risk cannot be ignored. Robust to earlier results we find a negative and significant ln(coast) variable indicating that the distance to coast is an important variable and The proximity to coast adds value to the properties in X zone. The distance dummies in model 2 again supports the importance of the distance to coast in the real estate market.

Table 6: Regression Results Using varying Flood Return Period within X zone.

VARIABLES	(Model 1)	(Model 2)	(Model 3)
100<rp<=250	-0.0115	-0.0290***	-0.0512
	(0.00941)	(0.00932)	(0.127)
250<rp<=500	-0.00856	-0.0236**	-0.353**
	(0.0102)	(0.0101)	(0.150)
500<rp<=1000	0.00484	-0.0234**	-0.285
	(0.0112)	(0.0109)	(0.215)
1000<rp<=5000	-0.0121	-0.0542***	-0.109
	(0.0137)	(0.0132)	(0.527)
Ln (coast)	-0.0700***		-0.0779***
	(0.00641)		(0.0112)
Ln(coast)*100<rp<=250			0.00443
			(0.0125)
Ln (coast)*50<rp<=500			0.0339**
			(0.0148)
Ln (coast)* 500<rp<=1000			0.0283
			(0.0206)
Ln (coast) *1000<rp<=5000			0.00976
			(0.0498)
coast_W500		0.468***	
		(0.0513)	
coast_W1000		0.127***	
		(0.0384)	
coast_W2000		0.135***	
		(0.0397)	
coast_W3000		-0.175***	
		(0.0398)	
coast_W4000		0.0485	
		(0.0389)	
coast_W5000		-0.0116	
		(0.0396)	
Structural attributes	Y	Y	Y
Location Attributes	Y	Y	Y
Year and Zip code FEs	Y	Y	Y
Constant	9.844***	9.351***	9.888***
	(0.151)	(0.146)	(0.177)

Lambda	0.00211	0.00188	0.00219
	(0.00167)	(0.00167)	(0.00167)
Rho	0.897***	0.899***	0.892***
	(0.0792)	(0.0784)	(0.0794)
Observations	21,702	21,702	21,702

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V. Concluding Comments

In this study, in addition to using the FEMA designated flood risk zones, we utilize varying flood return periods within those flood zones to determine the value that homeowner's place for the properties that are located in the lower flood return periods (i.e the riskier areas). Those properties located in the lower return periods, however, are near the coast making them more desirable to live in. Therefore, we attempt to tease out the tradeoff between the flood risk and the coastal amenity. The overall pattern of finding offers an evidence that the coastal amenities outweigh the negative effects of higher flood risk in Galveston County, Texas.

We find that the properties located in high-risk areas such as V and A zones command a price premium of up to 146%. Similarly, the those properties that fall within a return period less than 10 year sell for a higher price in V zone and also in the A zone. Although the most high-risk homes appear to command a price premium, we find that this premium decreases as the distance from the coast increases. Since distance to coast is an important determinant of the price of the property we interacted coastal distance with the flood return period and in almost all cases in the Vzone and the Azone the coefficient of the interacted variable was found to be negative and significant suggesting that the premium declines as the distance from the coast increases. This phenomenon suggests that the higher risk zones (lower return periods) provide amenity values that outweighs the risk and is associated with higher property prices.

The assertion that the risk-based premiums will cause property values to steeply decline and make homes unsellable, hurting the real estate market doesn’t seem to apply. It seems that the significant amenity value provided by the nearby coastal water shadows the risk and therefore masks the influence of increased flood insurance premiums on property prices.

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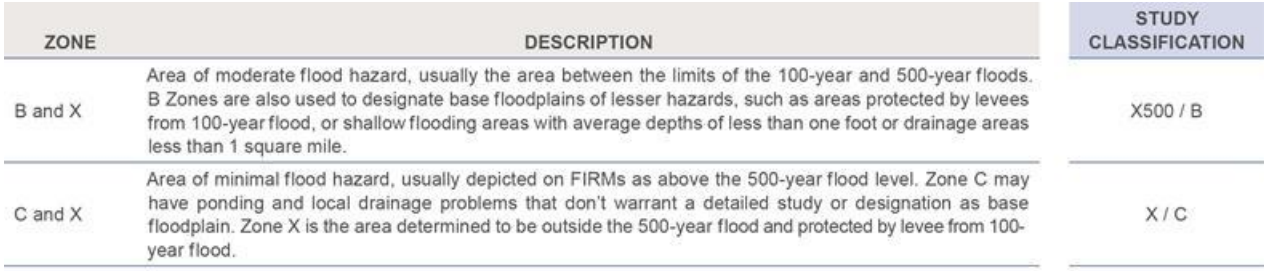
APPENDIX: Definitions of FEMA Flood Zone Designations

Flood zones are geographic areas that the FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.

Moderate to Low Risk Areas

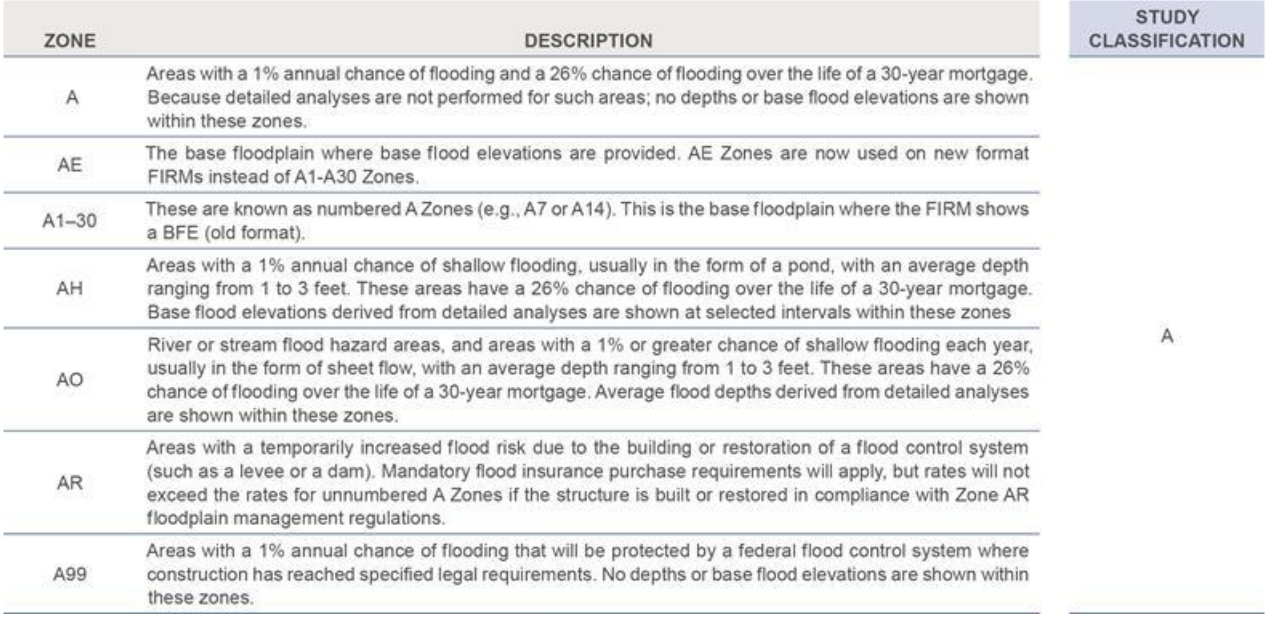
In communities that participate in the NFIP, flood insurance is available to all property owners and renters in these zones:



ZONE	DESCRIPTION	STUDY CLASSIFICATION
B and X	Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.	X500 / B
C and X	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.	X / C

High Risk Areas

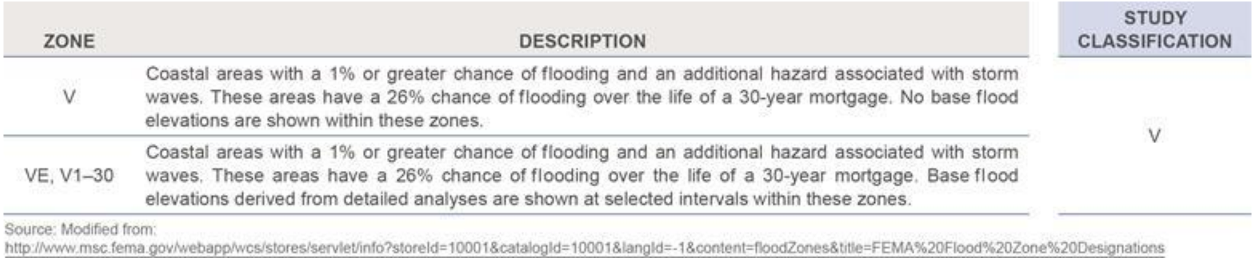
In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones:



ZONE	DESCRIPTION	STUDY CLASSIFICATION
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.	A
AE	The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.	
A1–30	These are known as numbered A Zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).	
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones	
AO	River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.	
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A Zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.	
A99	Areas with a 1% annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.	

High Risk - Coastal Areas

In communities that participate in the NFIP, mandatory flood insurance purchase requirements apply to all of these zones:



ZONE	DESCRIPTION	STUDY CLASSIFICATION
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.	V
VE, V1–30	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.	

Source: Modified from:
http://www.msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=floodZones&title=FEMA%20Flood%20Zone%20Designations

Source: Modified from:
http://www.msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=floodZones&title=FEMA%20Flood%20Zone%20Designations

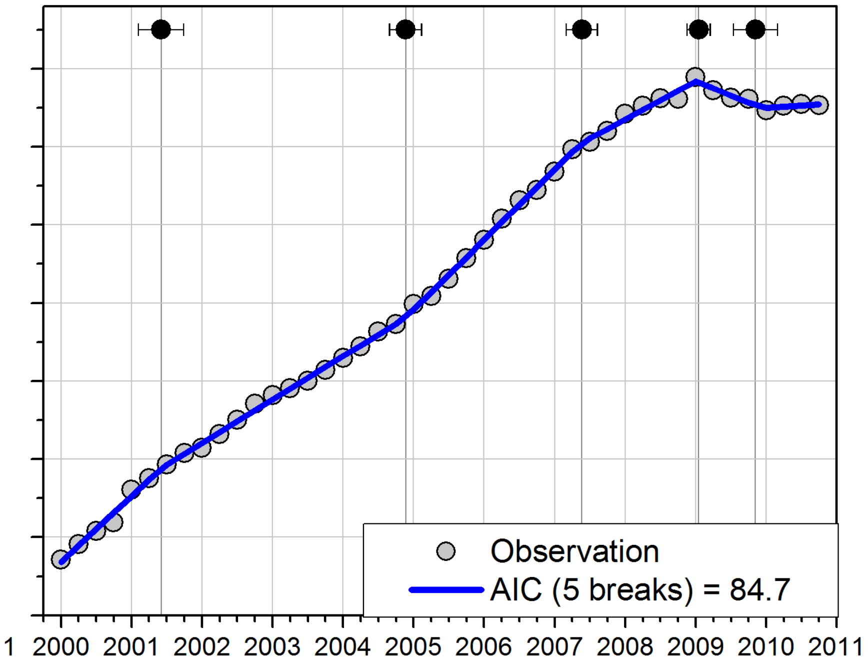


Figure 1: Time fixed effects from segmented regression on quarterly Houston–The Woodlands-Sugar Land FHFA HPI values.