THE VALUE OF BEACH QUALITY USING THE HEDONIC PRICING MODEL IN GALVESTON, TEXAS

A Thesis

by

ASHTON BURGIN

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MARINE RESOURCE MANAGEMENT

Chair of Committee,	Meri Davlasheridze
Committee Members,	Wesley Highfield
	Jens Figlus
Head of Department,	Kyeong Park

May 2016

Major Subject: Marine Resource Management

ABSTRACT

The hedonic pricing method is employed to estimate the value of quality beaches, including features such as beach width, presence of dunes, dune width, and proximity to a beach access point. Using the residential housing transaction data on Galveston Island from 2000-2014, and data on beach quality attributes, the implicit price associated with good quality beaches is revealed through the households' marginal willingness to pay for increased beach width. The results from this thesis indicates that the marginal willingness to pay for Galveston beaches, on average, is $161 per foot of beach. Thus for the average beach width of 124 feet, homeowners are willing to pay approximately $20,000. Given the sample size of 11,701, the total welfare derived from 1 foot increase of Galveston beaches is estimated at $1,883,861. The regression results also indicate that the MWTP per 1 foot of increased dune width is, on average, $229. This estimated MWTP yields a total welfare of $2,690,832 for a one foot increase of dune width.

Estimates of welfare measures associated with quality beaches represent an important component in benefits-costs calculation related to beach creation and nourishment policy. Beach nourishment projects are likely to continue due to frequent storms, projected sea level rise, and erosion impacting the quality of beaches in the Galveston area. This thesis aims to fill the research gap concerning benefits of beaches and nourishment projects to the residential housing market in Galveston.

ACKNOWLEDGEMENTS

I would like to thank Dr. Wesley Highfield and Dr. Jens Figlus for agreeing to serve on my graduate committee and for all the helpful information provided throughout the process of writing this thesis. I would also like to especially thank my committee chair, Dr. Meri Davlasheridze, for lending me your expertise, and for guiding me through this project from start to finish

Thank you to Anna Wood in the TAMUG Writing Lab for suffering through reading my rough draft and providing me with helpful edits and suggestions.

Thanks to the members of the Galveston Park Board Beach Maintenance Advisory Committee for providing me with information about beach nourishment on Galveston Island and for allowing me to present my research at your monthly meetings.

NOMENCLATURE

OLS	Ordinary Least Squares
IV	Instrumental Variable
IV SW	Instrumental Variable Sea Wall
GIS	Geographic Information Systems
MWTP	Marginal Willingness to Pay

TABLE OF CONTENTS

Page

1. INTRODUCTION

Management and improvement of beach quality has been an important coastal policy within many coastal communities. Beach management projects geared towards beach quality improvement vary across locations and encompass factors including beach width, presence of dunes, presence of shells, access to a pier, and many others depending on specific locations of coastline (Landry and Hindsley, 2011). Beach environments are highly dynamic, exhibiting continual erosion or accretion in response to natural processes such as longshore currents, waves, tides, and high-energy storms and winds (Landry and Hindsley, 2011). With more than half of the US population located within jurisdictions along coastal areas, development may exacerbate natural forces leading to either increased erosion or accretion (Landry and Allen, 2014). Sea level rise and other climate change factors could also lead to increased coastal erosion, threatening many coastal communities. In addition to increased erosion, inundation caused by rising sea level due to climate change can result in the permanent loss of beaches (Pendleton et al, 2011). Coastal erosion is particularly notable along the East Coast, where 80 to 90% of shoreline is experiencing a net loss of beach from erosion (Landry and Hindsley, 2011). An economic impact analysis of tourism done in Galveston in 2008 suggests that due to the high erosion rate along the Texas coast, the majority of Galveston beaches could disappear within 20 years if all beach nourishment were discontinued (Economics, 2008). Prior research indicates that there is a substantial price premium associated with quality beaches as reflected in coastal housing prices (Landry and Hindsley, 2011). These premiums likely capture perceived benefits of wider beaches by homeowners. In addition to the environmental amenity that beaches provide, both wider beaches and wider dunes provide protection from flooding and can add years to the life span of a beach facing increased erosion (Landry and Hindsley, 2011).

Galveston Island beaches are particularly vulnerable to high rates of erosion leading to a long-term loss of beaches. Some project that beaches located along the West End of the island could be fully lost by 2035 (Frey, 2014). Along with significant negative effects of eroding beaches on the island's important tourism sector, erosion also puts many residential homes located along the coast at an increasing risk from water encroachment. During the past 20 years, the West End of Galveston Island has experienced a housing boom and many homeowners identify erosion as their number one concern as gradual encroachment of water continues to threaten their property (Frey, 2014). Unlike other coastal areas where sand resources are plentiful and nourishment projects are relatively inexpensive, sand represents a scarce resource for Galveston Island. Sand is commonly dredged from offshore, or brought from outside the state of Texas, making frequent nourishment projects costly (Frey, 2014). Given this resource constraint, the large costs associated with restoration alternatives in Galveston are justified on the basis of the large benefits received from nourishment projects.

The largest nourishment project involved the addition of 27.6 million cubic yards of sand and was completed in 1995. An economic study performed after the completion of the project suggested that the nourishment led to a 3.14% annual growth of tourism and related recreational industries (Economics, 2008). These benefits in addition accrue to local governments in terms of increased tax revenues due to higher price premiums generated by an increase in beach quality. However, no comprehensive study has been performed to determine the economic value of good quality beaches for Galveston's homeowners both on the beachfront and elsewhere on the island. The latter can be substantial given that there is a significant flow of beach amenity accrued for beachfront property owners and this amenity is capitalized in the housing prices.

The main focus of this study is to understand and empirically estimate the value of quality beaches in Galveston, TX, as revealed by property homeowners’ marginal willingness to pay for improved beaches using the hedonic pricing method. The welfare estimates associated with quality beaches are compared with the cost of ongoing and future beach management projects to determine if these projects are favorable to the local community. Wider beaches would provide many benefits for Galveston Island specifically for tourists, recreation, and beach front home owners, all of which contribute significantly to Galveston’s economy (Economics, 2008). The results of this study reveal that wider beaches and wider dunes both have a statistically significant effect on housing prices. The estimated marginal willingness to pay for a one-foot increase in beach width is $161, while the value for an incremental increase in dune width is estimated at $229. These effects diminish with distance and the implicit price premium for wider beaches disappears beyond 4,500 feet away from the oceanfront.

Results arising from this project provide coastal planners, policymakers, and stakeholders with important information about the benefits associated with quality beaches to homeowners. A majority of beach nourishment studies completed on Galveston Island have focused on the cost of nourishment and have ignored the benefits of alternative management strategies. Economic benefits of beaches to homeowners will significantly complement both existing nourishment studies as well as current projects that are being undertaken to nourish segments of the Island's shorelines. Furthermore, estimating the effects of beaches and various beach quality attributes on nearby property prices represents an important piece of local public policy interest as new beaches are being proposed for construction along parts of the Island.

The rest of the thesis is organized as follows. Section 2 reviews the relevant literature, Section 3 describes the data and the regression results are provided in Section 4. Section 5 discusses these results in the context of ongoing beach construction projects. The last section, Section 6, concludes the thesis.

2. PREVIOUS LITERATURE

Houses are categorized as a differentiated or heterogeneous good. A differentiated good is a product with attributes that differ significantly so that there are distinctive product variations of the good present, even though it is sold in a single market (Champ et al, 2003). Due to these distinct variations in attributes there can be a wide variation of prices for differentiated good in the market. The hedonic method is a non-market valuation method that has been used to estimate the value of non-market goods and services associated with the houses sold and bought in a specific housing market. The main premise of the method is that housing prices are the function of various house, structural, neighborhood and location-specific attributes including environmental amenity or disamenity. This implies that environmental goods and services associated with housing locations can be assigned an implicit price that is linked to housing prices (Champ et al, 2003). This is most notable when two identical houses are sold for different prices, and the house closer to an environmental amenity (disamenity) is sold for a higher (lower) price. The difference in the prices of the two identical houses represents the implicit price of the nearby environmental amenity or disamenity.

Rosen presents a structure that can be used to portray the consumer’s marginal implicit price as a result of the homeowner's marginal value of housing characteristics and the supplier’s marginal cost of supplying these characteristics (1974). The hedonic model has been used frequently as an economic tool to determine consumer’s preferences for a specific house, and has been applied to determine values of environmental factors relevant for particular locations on the housing market. In these cases, housing markets are not only distinguished by the traditional housing characteristics including structure, neighborhood, roofing material, number of bathrooms, number of bedrooms, and total square footage, but also by the environmental characteristics found in the area. When applying this model, consumers will choose to buy a house with the most ideal collection of housing characteristics available within their financial means at the market's equilibrium price. Within a competitive market, the equilibrium price is assumed to be external to the consumers and producers, but adjusts as the total combined supply and demand of property characteristics changes. The basic price function for the hedonic model can be formulated as:

$$\ln(P)=X\beta+f(q,d)+u \quad (1)$$

where P represents the sales price, and X represents the vector of structural and neighborhood characteristics associated with houses. The differentiation of products within the housing market means that expansive arrays of alternative packages of characteristics are available to consumers. This vector of housing attributes will influence the outcome of the natural log of price (P) through the coefficient β, which represents the variable that affects prices. The function f(*q*,*d*) represents the relationship between the housing price, quality of environmental goods (q), and the distance from the environmental good (d). For the purpose of this research, *q* represents the quality of nearby beaches measured by beach and dune widths respectively, and *d* measures the distance from houses to the nearest beach.

Numerous studies have previously examined the value of environmental amenities in coastal areas within the hedonic framework and were able to reveal the homeowners' willingness to pay for the provision of the respective amenity or environmental services. Examples of hedonic valuation studies include estimating the value of water amenity proxied by the vicinity to water (Shabman and Bertelson 1979; Milon, Gressel, and Mulkey 1984; Edwards and Gable 1991; Pompe and Rinehart 1995; Earnhart 2001; Parsons and Powell 2001; Landry, Keeler, and Kriesel 2003; Bin, Kruse, and Landry 2008), the value of unobstructed water view (Kulshreshtha and Gillies 1993; Lansford and Jones 1995; Pompe and Rinehart 1999; Bin et al. 2008), and the overall quality of the water (Leggett and Bockstael 2000). All of these studies find that the presence of water as an environmental amenity is associated with a significant price premium in coastal communities. Another application of the hedonic model includes estimating the price associated with coastal disamenity such as flood (Hallstrom and Smith 2005; Bin, Kruse, and Landry 2008; Bin et al. 2008) and wind hazard (Simmons, Kruse, and Smith 2002), as well as erosion (Kriesel, Randall, and Lichtkoppler 1993; Landry, Keeler, and Kriesel 2003). They all estimate that risk is negatively capitalized in the housing market, which reveals consumers' willingness to pay for the avoidance of these coastal risks.

While it has been shown that nearby environmental amenities affect housing prices, individuals perceptions of the quality of natural resources and their expectations of future management of that resource may differ (Landry and Hindsley, 2011). For homeowners who do not consider the dynamic nature of beach environments, perception of beach quality is likely static and benefits from beach quality are viewed similar to structural characteristics within the hedonic model. For those who do expect beach quality to degrade over time, marginal willingness to pay estimates may be an overestimate. Due to these perceptional differences estimates of willingness to pay for beach quality may be upward or downward biased. Not surprisingly, these estimates vary widely in studies. For example, Landry and Allen suggest that homeowners' on Tybee Island on average are willing to pay $71 to $196 per additional meter of high tide beach (2014). This value is higher for houses located closer to the beach. Landry and Allen estimates that the average willingness to pay for houses located in close proximity to the beach increases from $421 to $487 for an additional meter of high tide beach (2014). Data was obtained from the Dare County Tax Accessor website and included property sales from 1997 and 1998 with a total of 1,962 observations. The study performed by Landry and Hindsley in Dare County, North Carolina, also takes into account the proximity effect within their regression models and estimates a marginal willingness to pay of $75 to $583 for an additional foot of beach (2011). The study area was Tybee Island, located off the coast of Georgia, and data included houses bought and sold from January 1990 to December 1999 with a total of 372 observations. The proximity effect was also included and benefits from increased beach width were estimated to diminish to zero at 300 feet away from the shoreline. Another study in North Carolina found the additional price of 1 foot of beach on average is $1,440 (Gopalakrishnan, 2011). In this study, the effect of beach quality on housing prices nearly diminishes around 330 feet away from the oceanfront. Gopalakrishnan (2011) also estimates the instrumental variable regression, as they argue that beach width could possibly be endogenous to property prices due to the role of property values in the decision making for placement of beach nourishment projects. Although each study finds varying ranges for marginal willingness to pay, each study finds that beach quality, specifically beach width, is capitalized within coastal housing markets and that these benefits are impacted by proximity to the shoreline.

3. STUDY AREA AND DATA

The study area covers the city of Galveston located on Galveston Island. Galveston Island represents a barrier island located off the Gulf Coast of Texas, about 50 miles south west of the Houston Metropolitan area. The data on residential property prices and housing structural characteristics for the city of Galveston were obtained from CoreLogic, Inc., the largest property transaction provider in the nation. The data includes single-family housing units bought and sold during 2000-2014. Figure 4 displays sample parcels outlined in blue. Several missing observations for property sales prices were encountered in the dataset and instead of discarding these missing observations, they were replaced with tax appraisal values in the same year, obtained from the Galveston County Central Appraisal District. To construct house-specific explanatory variables the data from the CoreLogic was again supplemented by the data from the Galveston County Central Appraisal District. The housing characteristics commonly used in the hedonic model were selected. These included the number of bathrooms, land acres, building square footage, age, number of stories, presence of a garage, a pool, air-conditioning and central heating, foundation type and the quality of a house assessed by a Tax Appraisal Agent. A presence of a garage is represented by a dummy variable that equals one for houses with a garage and zero otherwise. Dummy variables were also created for the presence of a pool (yes = 1, no = 0), type of foundation represented by pier and stone, presence of a fireplace, presence of air conditioning, presence of central heating. The quality of a housing structure is assigned a value of one if the house is in a good to excellent conditions as assessed by tax appraisal and zero for relatively poorer quality houses.

Beach quality factors included were proximity to beach access points, beach widths, presence of dunes, and corresponding dune widths. The beach access points were obtained from the City of Galveston GIS department as a shapefile, which was viewed on Geographic Information System (GIS) software. The shapefile was developed to spatially reference the beach access points in accordance with Texas Code, which requires a beach access point every 0.5 miles of an inaccessible beach. Aerial photographs were used to identify and include the individual beach access points along the seawall through the selection of stairways, which allow access to the beach from the top of the seawall. These beach access points are shown in Figure 5, represented by the blue dots along the shoreline. In total, 114 beach access points were spatially referenced. Beach widths were measured at each of these beach access points using the measure tool in GIS, which allows for the straight line measure of distance between two points in space. This process is demonstrated in Figure 6, with the shoreline represented by a red line, and the beach access points represented by blue dots. These widths were calculated from the beach access point up to the shoreline, which was provided as a shapefile by the City of Galveston. To differentiate beach widths for each property, beach width at each access point was multiplied by the distance between each parcel and the nearest beach access point, calculated using a spatial join tool in ArcGIS. Dune data was also obtained from the City of Galveston and included the north and south toes of dunes present on the island. These widths were measured at each access point and are calculated as the straight-line distance between the north toe dune line and the south toe dune line. Dune widths were assigned to each parcel based on the nearest beach access point. Figures 7 and 8 show the dunes lines used to measure widths on the west end and the east end, respectively. For areas where no dunes were present, the width was coded as zero.

Table 1 presents the summary statistics for all model variables. Property sales prices were converted to real 2014 prices using the Urban Consumer Price Index. The total number of observations in the sample is 11,701 and includes houses sold and bought during 2000-2014. The average sample sales price is $173,363. This is equal to 11.78 in log term. All prices were converted into log terms to ensure the data had a normal distribution, which is necessary for regression analysis. The minimum log price was 7.39, the maximum value was 16.36 and the standard deviation was 0.73. The average age of a house was 39 years, with a minimum age of 0 for houses built and sold in the same year, a maximum age of 168 years, and a standard deviation of 22.03. The average acreage of a parcel on Galveston Island was 0.17 acres, with a minimum value of 0.02 acres, a maximum value of 12.88 acres and a standard deviation of 0.33. The average square footage of the houses located on each parcel was 1,730 sq. ft., with a minimum value of 240 sq. ft., a maximum value of 25,495 sq. ft., and a standard deviation of 845.88. On average, a house contained 1.8 bathrooms, with a minimum value of 1 bathroom, a maximum value of 10 bathrooms and a standard deviation of 0.87. The average beach width was 124 feet, with a minimum value of 0 feet for areas along the coast where a beach is not present, a maximum value equal to 702 feet, and a standard deviation of 125.67. The maximum for beach width of 702 feet was found on the east end where the beaches present are, on average, accreting. The minimum beach width of 0 is found mostly along the seawall in the middle of the island where erosion rates are high. Dunes were on average 21.55 feet wide, with a minimum width of 0 feet, a maximum width of 303 feet, and a standard deviation of 43.93.

4. METHODS

In the hedonic model, the price of an individual property (P_{it}) is a function of the property's structural attributes (X_{it}), distance from the nearest beach (d_i), width of beach at nearest access point (W_i), and (λ_t) which captures year-specific effects that are common across houses. The following equation relates these variables.

$$ln\ (P_i)\ = \alpha X_{it} + \beta d_i + \beta W_i d_i + \lambda_t + \varepsilon_{it}\ \ (2)$$

Where (X_{it}) represents a vector of the structural characteristics of individual properties, and as discussed in the data section includes age of the property (years), total acres of property, square footage of building, total number of bathrooms, presence of a garage, presence of a pool, presence of air conditioning, presence of central heating, pier and stone foundation type, presence of a fireplace, number of stories, and the quality of the building. To capture nonlinear (diminishing) effects of some of the structural features the model includes the square terms of age, acres, property square footage, and the number of bathrooms. These attributes are considered nonlinear (diminishing) because there is a diminishing return associated with a one unit increase of each of these attributes. The beach quality attributes include the width of the beach at each access point, product of the beach widths and the distance from the property to the nearest beach, the presence or absence of dunes at the nearest beach multiplied by the corresponding width of any present dunes. Beach quality for Galveston beaches is assumed to be constant during this sample period, which may seem a restrictive assumption given the dynamic processes affecting beaches, in addition to changes from nourishment projects. No consistent data exists that tracks changes of beaches over time for Galveston Island. The last major beach nourishment project was completed in 1995, before the sample time frame. Any changes from natural erosion or accretion rates are assumed to be similar across the island and these effects are likely captured by the year fixed effects within the model. One important variable currently excluded from the model is the flood plain type. This variable was not included in the regression model as there were only three unique flood plain types found on Galveston Island. This low variability in flood plain types led to statistically insignificant results associated with this variable. In addition, the flood plain designation for Galveston is likely outdated and inaccurate. The effects of hurricanes and flood events (e.g. Hurricane Ike) and the effect of these events on changes in insurance prices are likely captured by the year fixed effects in the regression model.

To estimate the hedonic model presented in equation (2), first the ordinary least squares (OLS) regression model was used. This model assumes that beach quality is exogenous to the price of the property. This assumption may not hold if policies targeting beach nourishment and maintenance also account for housing values (Gopalakrishnan et al., 2011). In some communities, beach nourishment can be employed in neighborhoods where property prices are high in order to reduce beach erosion, therefore increasing the width of beaches. In such cases, beach width is likely endogenous to the price of properties. To account for this endogenous problem, the instrumental variable (IV) model is also estimated. The basic assumption of the IV model is to identify variables that are highly correlated to the endogenous variable of interest (e.g. beach quality), but are uncorrelated with the error term and thus housing prices. Similar to Gopalakrishnan et al. (2011), the IV variable used was the distance from the shoreline to the 20-meter bathymetry line on the continental shelf. The bathymetry data for Galveston Island was obtained from the Houston-Galveston Area Council GIS Dataset. This distance is correlated to the slope of the shore face profile, which can affect beach erosion, and in turn beach widths. Shorter distances between the shoreline and the 20 meter isobath result in a higher slope and a higher rate of erosion. Therefore, this variable is correlated with the beach width, but is not directly correlated with property prices. The IV model involves estimating a two-stage regression model. In the first stage, the endogenous variable is regressed on the instrumental variable with all other exogenous variables included in the hedonic equation. In the second stage, the hedonic regression model is estimated and the fitted beach width from the first stage is used in lieu of the actual beach width as a way to control for the endogenous bias.

Since the dependent variable is given in logarithmic term, the average marginal willingness to pay for an incremental change in the beach width and its dependence on distance is calculated as:

$$\text{MWTP} = (\beta_{BW} + \beta_{BW_d} Distance) \cdot P_{avg} \quad (3)$$

Where (β_{BW}) and (β_{BW_d}) are regression coefficients associated with beach width and the distance weighted beach width variables respectively, and(P_{avg}) is the average sample house price. The MWTP for 1 foot of dunes is calculated as the product of the coefficient associated with dune widths(β_{DW}) and the average housing price (P_{avg}). Multiplying these MWTP estimates by the total number of sample houses gives the total welfare measure associated with beach quality attributes in Galveston Island.

For all other attributes presented by continuous variables in the regression, marginal effect is calculated as the product of their corresponding regression coefficient and the average housing prices.

$$\text{MWTP} = \beta_x \cdot P_{avg} \text{ (4)}$$

If the attribute is also presented as a squared attribute, the MWTP is calculated using equation (5).

$$MWTP = (\beta_x + 2\beta_{sq\_x}) \cdot P_{avg} \text{ (5)}$$

Last, the coefficients associated with dummy variables (dummy=1) are interpreted as percentage difference in prices relative to omitted category (dummy=0).

5. RESULTS

Table 2 reports the results from the OLS model and reveals a statistical significance for all of the beach quality attributes as well as most of the structural attributes. Column (1) of the OLS model results includes distance from parcel to shoreline as a standalone variable and column (2) does not. All MWTP calculations are based on column (2). Asterisks noted after each attribute's coefficient represent statistical significance, with one asterisk corresponding to 10% significance level, two asterisks representing 5%, and three representing significance at 1%. As shown in the table, age, building square footage, number of bathrooms, presence of garage, presence of a pool, presence of a fireplace, presence of air-conditioning, presence of central heating, number of stories, and quality of the house are all highly significant at less than 1% significance level and have expected signs. Coefficients associated with beach width, distance weighted beach width, and dune widths are also significant at less than 1% level. The results from the OLS regression model revealed a MWTP for a one-foot increase of beach of $129 for a beachfront property. When accounting for the effect of distance, as shown in figure 4, values decrease to 0 at around 3000 feet away from the beachfront. At the average distance of 3,655 feet away from the beach front in our sample, the MWTP per foot of beach is less than $0. The average MWTP for 1 foot increase in dune width using the OLS model is estimated on average at $482.

Table 4 reports the results of the IV regression model. Column (1) includes the distance from parcel to shoreline as a standalone variable and column (2) does not. All

MWTP calculations are based on column (2). As noted above, this model corrects for the possibility of endogeneity of beach quality and housing prices, using the instrumental variable, which measures the distance from the shoreline to the 20 meter isobath. Table 3 reports the results from the first stage of the IV model, in which the dependent variable represents beach widths. The validity of the instrumental variable (distance from the shoreline to the 20 meter isobath) is judged using the F-statistics from the first stage regression. The F-statistic 15.63 is greater than ten, the rule of thumb critical value. Within the IV regression model results, all beach quality attributes and most of the structural attributes remain statistically significant and have expected signs. Foundation type and dune width are both significant at the 10% significance level. Presence of air-conditioning is significant at the 5% significance level. Coefficients for age of building, number of acres, building square footage, total number of bathrooms, presence of a garage, presence of a pool presence of a fireplace, presence of central heating, quality of house, beach widths, and distance weighted beach widths are all highly significant at less than 1% significance level.

The marginal effects associated with structural characteristics, on average, is $40,592.95 per acre, $76.28 per square foot of building, and $24,092.26 per bathroom. The overall price was found to decrease $3,455.12 for every additional story and $1,133.79 for each additional year of age. Houses with a garage, on average, sell at 28.81% higher prices relative to houses with no garage, presence of a pool increases the price by 13.49%, presence of a fireplace increases the price by 19%, the presence of air-conditioning increases the price by 11.04%, the presence of central heating increases the price by 11.81%, and a good to excellent quality houses on average sell 12.73% higher than those of low quality. All else held constraint, the houses with the chosen foundation type (i.e. pier and stone) sell on average by 5.45% less than the houses with other foundation types.

Using this model, the MWTP for a 1 foot increase of beach width, on average, is approximately $161. The estimated MWTP also varies with distance from the shoreline and is approximately $813 per foot of beach width for beach front homes and declines with distance. This estimate is higher than the one estimated from the OLS model, which suggests that beach widths are truly endogenous and the OLS model underestimates true effects of these environmental attributes. As shown in Figure 2, these MWTPs decrease by distance from the shoreline, diminishing to zero at around 4,500 feet. The calculation for the MWTP for one foot of increased dune width using the IV regression model yields an estimate of $229. Using these MWTP estimates, and the total number of sample houses, the total welfare derived from the quality wide beaches in Galveston, as revealed by home owners, is approximately $1,887,436 per 1 foot, while the total benefit of wide dunes is approximately $2,690,832.

Table 5 shows the IV regression model results from the sample of properties located behind the seawall. A 17-mile long seawall line was drawn in GIS using satellite imagery, and those parcels located behind the seawall were separated from parcels elsewhere on the island. It is assumed that the parcels located directly behind the seawall will receive all of the flood protection benefits from the presence of the seawall. After removing parcels that are not located behind the seawall, our sample size reduced to

9,374 parcels. All attributes are statistically significant and have expected signs. The MWTP on average for 1 foot of beach using the IV SW model results is $11 per foot. The MWTP on average for beach front homes, located at the minimum distance of 210 feet away from the seawall, is $335 per foot of beach and diminishes to $0 at around 3,800 feet away from the seawall, shown in Figure 3. Using the IV SW regression model results, the MWTP on average for a 1 foot increase in dune width is $920. These estimates yield a total welfare for width of Galveston beaches of $106,176 per foot, and a total welfare for dune width of $8,629,306 per foot. A regression model results for parcels not located behind the seawall was not reported as the results exhibited lack of statistical significance. This may be due to the small sample size, or a low variability in attributes found on the west end of Galveston.

6. DISCUSSION

The results of this study indicate that beach quality factors have important effects on market values for Galveston Island properties, however these benefits diminish with the distance from the shoreline. The distance at which benefits from increased beach width disappears was estimated at 4,500 feet away from the beachfront. The estimated willingness to pay per one foot of additional beach on average is $161. When accounting for the effect of proximity, those in close proximity (0 feet to 300 feet) are willing to pay between $813 and $760 per foot of beach. The total welfare for Galveston beaches, based on a sample size of 11,701, is $1,883,861 on average, per foot of increased beach width. For the average beach width of 124 feet, this welfare estimate is approximately $20,000 per property. The effects of dunes are also found to be capitalized in the housing prices, the results suggesting the MWTP on average per foot of dune at approximately $229, yielding a total welfare estimate of $2,690,832.

In 2015, a new beach was created from 61st to 75th street by the city of Galveston. The project involved the movement of 629,188 cubic yards of dredge material onto the beach in the area between 61st and 75th street (Figure 9). As of January 2016, 57% of the material, or 357,000 cubic yards, remained within the desired area, creating a 4,900 foot long beach that is on average around 230 feet wide. The total cost of the project was $7,843,392.8 and the new beach created had an area of 1,108,427 square feet. This area yields a unit cost of $7.08 per linear foot of beach width. When compared to the sample average marginal willingness to pay for a 1 foot increase of beach width, the estimated benefits of \$161 is much higher than the cost per square foot of beach creation. However, these benefits are higher than \$161 as wide beaches can provide benefits for more than one year. Due to the lack of data on Galveston, there is no good estimate for the historic beach life cycle for Galveston beaches. Using the average lifetime of 10 years for beach nourishment projects from the literature (Gopalakrishnan et al 2011) the net present value of benefits is estimated using equation (6). The net present value of beaches associated with 1 foot of beach creation is approximately \$1,345 on average per foot at the 6% discount rate. This suggests that there is strong evidence of benefits from beach widths for Galveston residents, and that this project was completed for a cost that is appropriate when compared to the estimated value placed on beach width by residents.

$$NPV\ of\ Benefits = \sum_{t=0}^{10} \frac{MWTP}{(1+r)^t} \quad (6)$$

If beach width is found to have a significant effect on property prices, the increase of beach width in an area through beach nourishment will also increase the value of the property (Pompe et al., 1995). Using the results from the IV regression presented in Table 4, the predicted property value increases at different distances from the beachfront are reported in Table 6 for both a beach of 124 feet and 200 feet, wide respectively. These distances were chosen because the average width of Galveston beaches is 124 feet and the average width of the most recent beach nourishment was approximately 200 feet wide. The estimated increase in property values decreases with distance. Using the average distance from the shoreline of 3,655 feet, for the entire sample an increase of beach width from 0-124 feet would increase housing prices by \$159,393,362.20 per year. Similarly, the estimated increase in property values, associated with an increase of beach width from 0-200 feet is $265,159,871.30 per year. These benefits are passed to local governments in terms of increased tax revenues. Increased tax revenues are also important to finance and support many local public projects including local beach nourishments (Houston, 2013). To calculate the average increase in tax revenue attributed to wider beaches, the Galveston property tax rate was obtained from the Galveston tax assessor website. The current rate is $0.55 for every $100 of assessed property value. Using this tax rate, the estimated increase in property tax revenue associated with increased property values is reported in Table 7, differentiated by properties at different distances from the beachfront and are reported for a beach width increase from 0-124 feet and 0-200 feet, respectively. The estimated total increase in property tax revenue, on average, per year for an increase of beach width from 0-124 feet is $876,663.49 for the entire sample. This figure is approximately $1.5 million when beach width is 200 feet.

According to Paine et al (2012), the Texas shoreline is one of the most dynamic coastal environments with a relatively high erosion rate that may increase in the near future due to present and future development, sea-level rise, and increased storm intensity and frequency. The results of this thesis support that benefits of quality beaches are captured in the Galveston housing market, which could be negatively impacted if beaches continue to disappear as a result of increased erosion along the Texas Coast. In order to continue to reap the benefits from quality beaches, it is recommended that the city of Galveston continue investing in beach nourishment projects in order to sustain or increase beach widths on a more regular basis.

7. CONCLUSION

This thesis employs the hedonic pricing method to estimate the benefits of improved and quality beaches in Galveston, Texas. Using the sample of houses bought and sold during 2000-2014, the estimated MWTP per 1 foot increase of beach width is $161. This value is $813 for beachfront properties and diminishes with distance from shoreline at around 4,500. This estimate yields a total welfare for Galveston beaches of $1,887,436 and $20,064 for the average beach width on the island. The benefits for wider dunes were also found to be significant and were estimated at $229 per one foot of increased dune width, with a total welfare of $2,690,832. The results suggest that homeowners positively perceive both the recreation and environmental benefits such as mitigating flood impacts provided by wider beaches and dunes. Comparing actual cost associated with a foot increase of recently completed new beach indicates that the benefits significantly outweigh the costs of beach creation, which reflects homeowner's preferences for policies geared towards more frequent nourishment, restoration, and new beach creation.

Based on these estimates, this thesis finds strong empirical evidence that benefits from quality beaches are captured within the housing market, which warrants more consistent beach management, maintenance, and creation. Due to the dynamic nature of the coastal environment and the high erosion rates found along the Texas coast, beach nourishment projects should become more frequent to continue capturing these benefits in the housing market. The optimal nourishment interval should take into account the

MWTP estimated from the empirical hedonic method (Gopalakrishnan et al 2011), and be determined within the dynamic resource framework, which accounts for the dynamic natural processes affecting beaches, as well as the discounted future costs and benefits of nourishment projects. Identifying frequency of nourishment cycles will be an interesting extension of this research.

REFERENCES

Bin, O., Crawford, T. W., Kruse, J. B., & Landry, C. E. (2008). Viewscapes and Flood Hazard: Coastal Housing Market Response to Amenities and Risk. *Land Economics*, *84*(3), 434-448.

Champ, P. A., Boyle, K. J., Brown, T. C. (2003). *A Primer on Nonmarket Valuation.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Earnhart, D. (2001). Combining Revealed and Stated Preference Methods to Value Environmental Amenities at Residential Locations. *Land economics*, *77*(1), 12-29.

Economics, A. (2008). Galveston Island: Tourism Economic Impact Analysis (unpublished report). Retrieved from: http://www.cityofgalveston.org/DocumentCenter/Home/View/215

Edwards, S. F., & Gable, F. J. (1991). Estimating the Value of Beach Recreation from Property Values: an Exploration with Comparisons to Nourishment Costs. *Ocean and Shoreline Management*, *15*(1), 37-55.

Frey, A. E., Morang, A., & King, D. B. (2015). Galveston Island, Texas, Sand Management Strategies. Retrieved from, http://repositories.tdl.org/tamug-ir/handle/1969.3/28623

"Galveston." 29◦15'43.09' N and 94◦49'54.95' W. Google Earth. November 21, 2015. Accessed March 1, 2016.

Gopalakrishnan, S., Smith, M. D., Slott, J. M., & Murray, A. B. (2011). The Value of Disappearing Beaches: A Hedonic Pricing Model with Endogenous Beach Width. *Journal of Environmental Economics & Management*, *61*(3), 297-310. doi:10.1016/j.jeem.2010.09.003

Hallstrom, D. G., & Smith, V. K. (2005). Market Responses to Hurricanes. *Journal of Environmental Economics and Management*, *50*(3), 541-561.

Houston, J. R. (2013). The Economic Value of Beaches: A 2013 Update. *Shore and Beach*, 81(1), 3-11.

Kriesel, W., Randall, A., & Lichtkoppler, F. (1993). Estimating the Benefits of Shore Erosion Protection in Ohio's Lake Erie Housing Market. *Water Resources Research*, *29*(4), 795- 801.

Kulshreshtha, S. N., & Gillies, J. A. (1993). Economic Evaluation of Aesthetic Amenities: A Case Study of River View. *Journal of the American Water Resources Association, 29(2),* 257-266.

Landry, C. E., & Allen, T. (2014). Hedonic Property Prices and Coastal Beach Width. *Available at SSRN 2474276*.

Landry, C. E., & Hindsley, P. (2011). Valuing Beach Quality with Hedonic Property Models. *Land Economics*, *87*(1), 92-108.

Landry, C. E., Keeler, A. G., & Kriesel, W. (2003). An Economic Evaluation of Beach Erosion Management Alternatives. *Marine Resource Economics*, *18(2),* 105-127.

Lansford Jr, N. H., & Jones, L. L. (1995). Recreational and Aesthetic Value of Water Using Hedonic Price Analysis. *Journal of Agricultural and Resource Economics, 20(2),* 341-355.

Leggett, C. G., & Bockstael, N. E. (2000). Evidence of the Effects of Water Quality on Residential Land Prices. *Journal of Environmental Economics and Management*, *39*(2), 121-144.

Milon, J. W., Gressel, J., & Mulkey, D. (1984). Hedonic Amenity Valuation and Functional Form Specification. *Land Economics*, *60(4),* 378-387.

Paine, J. G. (2012). Historical Shoreline Change Through 2007, Texas Gulf Coast: Rates, Contributing Causes, and Holocene context.

Parsons, G. R., & Powell, M. (2001). Measuring the Cost of Beach Retreat. *Coastal Management*, *29*(2), 91-103.

Pendleton, L., King, P., Mohn, C., Webster, D. G., Vaughn, R., & Adams, P. N. (2011). Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches. *Climatic Change*, *109*(1), 277-298.

Pompe, J. J., & Rinehart, J. R. (1995). The Value of Beach Nourishment to Property Owners: Storm Damage Reduction Benefits. *The Review of Regional Studies*, *25*(3), 271.

Pompe, J. J., & Rinehart, J. R. (1995). Beach Quality and the Enhancement of Recreational Property Values. *Journal of Leisure Research*, *27*(2), 143.

Rinehart, J. R., & Pompe, J. J. (1999). Estimating the Effect of a View on Undeveloped Property Values. *Appraisal Journal*, *67,* 57-61.

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy, 82*(1), 34-55. Retrieved from http://www.jstor.org/stable/1830899

Shabman, L., & Bertelson, M. K. (1979). The Use of Development Value Estimates for Coastal Wetland Permit Decisions. *Land Economics*, *55(2)*, 213-222.

Simmons, K. M., Kruse, J. B., & Smith, D. A. (2002). Valuing Mitigation: Real Estate Market Response to Hurricane Loss Reduction Measures. *Southern Economic Journal*, *68(3)*, 660-671.

APPENDIX A

FIGURES

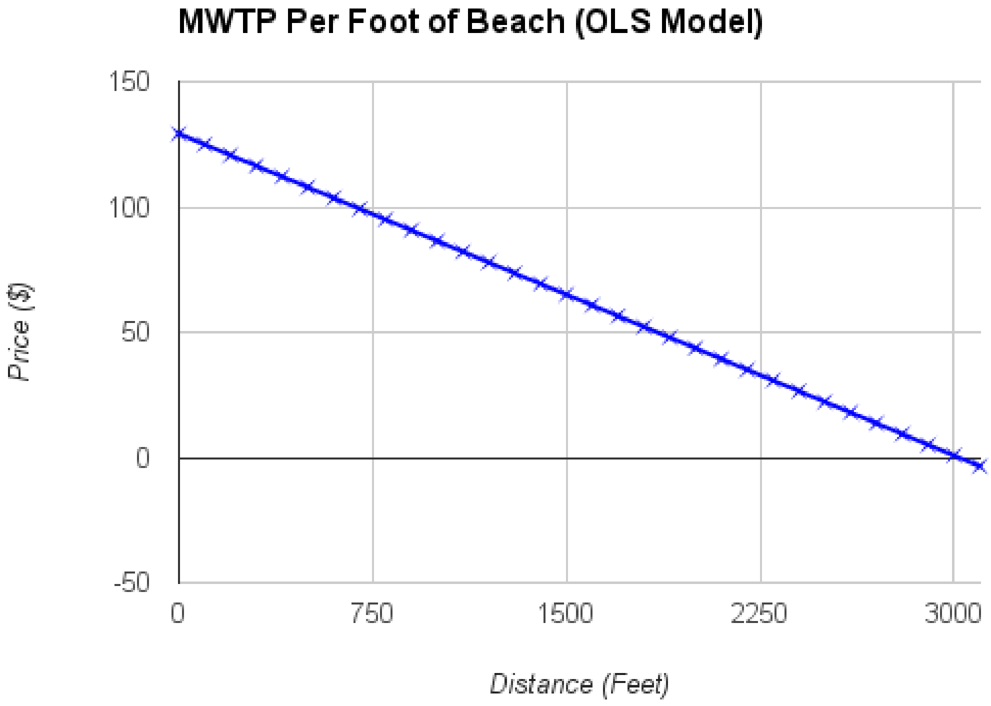

Figure 1 MWTP per Foot of Beach (OLS Model)
Notes: This figure displays the MWTP per 1 foot increase of beach using OLS regression model results. The MWTP is interacted with distance and benefits appear to decrease to $0 around 3000 feet away from the shoreline.

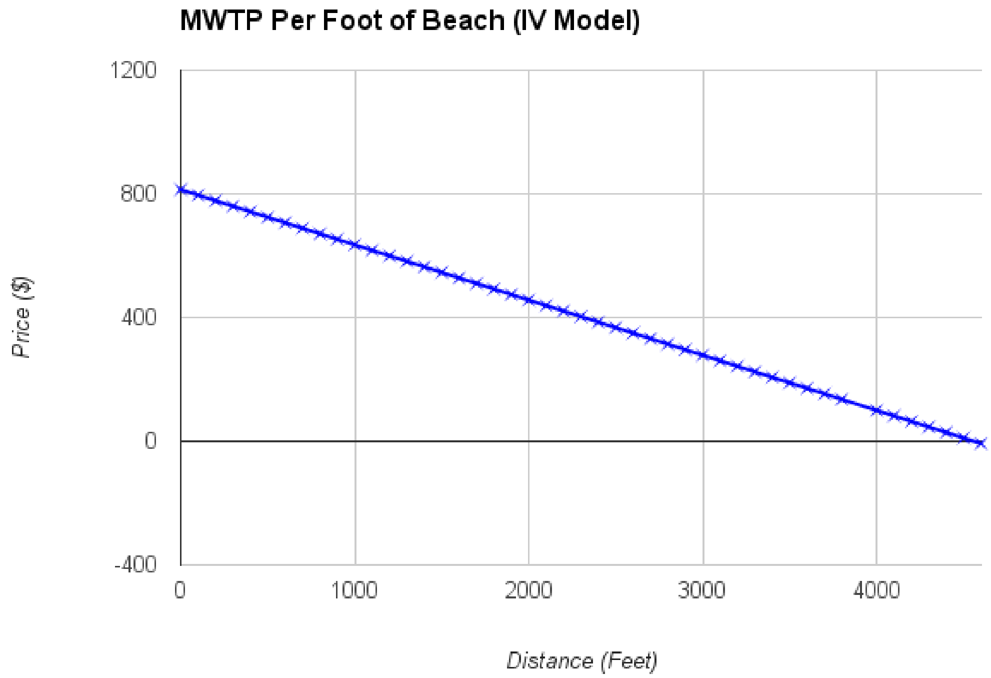

Figure 2 MWTP Per Foot of Beach (IV Model)
Notes: This figure displays the MWTP per 1 foot increase of beach using the IV regression model results. The MWTP is interacted with distance and benefits appear to decrease to $0 around 4,500 feet away from the shoreline.

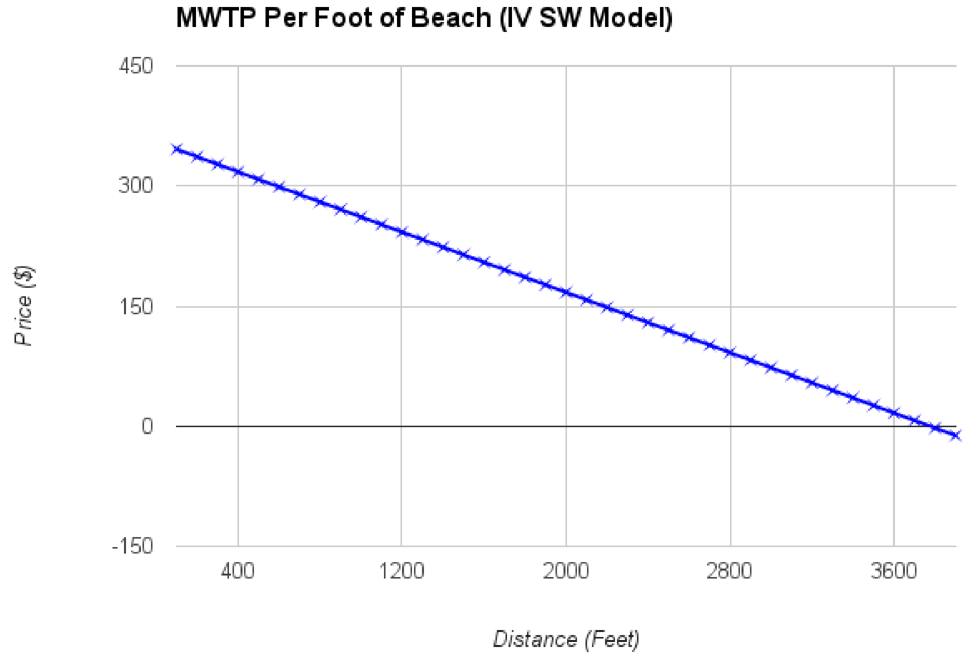

Figure 3 MWTP per Foot of Beach (IV SW)
Notes: This figure displays the MWTP per 1 foot increase of beach using the IV SW regression model results. The MWTP is interacted with distance and benefits appear to decrease to $0 around 3,800 feet away from the seawall.

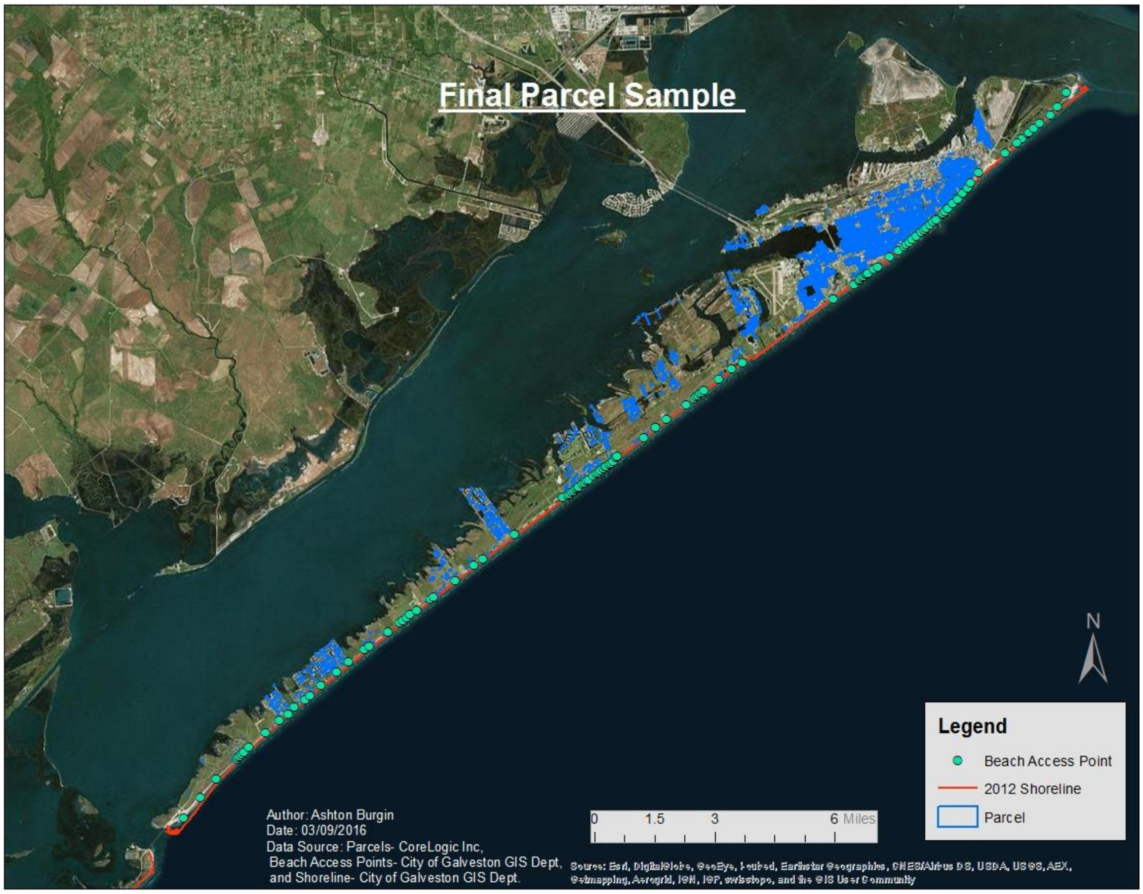

Figure 4 Galveston Island Parcel Sample
Notes: This map displays the parcel sample used on Galveston Island and includes parcels bought or sold from 2000-2014, along with beach access points, and the Galveston shoreline. This data was obtained from CoreLogic Inc. and there are a total of 11,701 observations in the final sample.

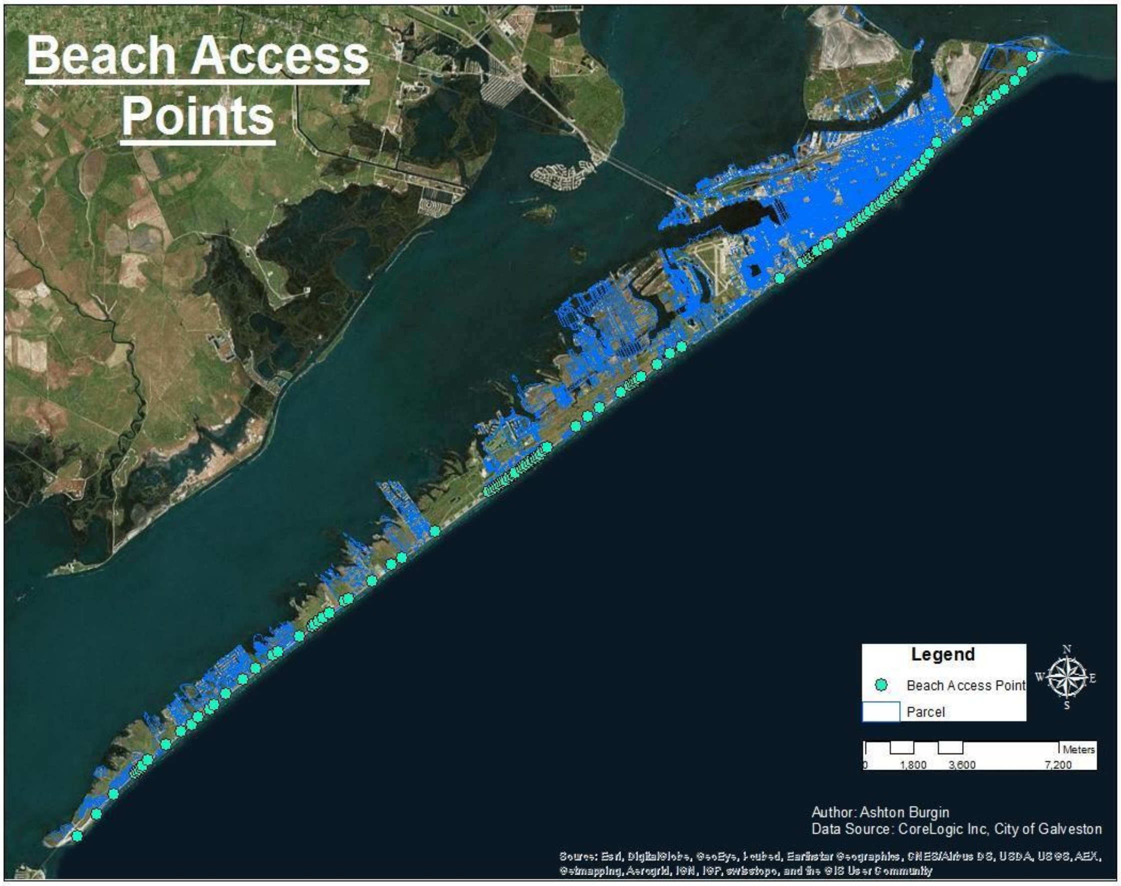

Figure 5 Beach Access Points

Notes: This map displays the parcel sample used along with beach access points used to determine where beach width values were measured. Beach access points were either obtained from the City of Galveston or identified using satellite imagery in GIS.

Figure 6 Beach Widths
Notes: This map depicts the beach access points, parcel sample, and the shoreline used to measure beach widths. Beach width values were obtained by measuring from each access point to the shoreline in GIS.

Figure 7 East End Dunes
Notes: This map depicts the parcel sample, and the north and south toe dune lines on the east end of Galveston. Dune width values were obtained at every beach access point by measuring from the north toe line to the south toe line in GIS.

Figure 8 West End Dunes
Notes: This map depicts the parcel sample and the north and south toe dune lines on the west end of Galveston. Dune width values were obtained at every beach access point by measuring from the north toe line to the south toe line in GIS.

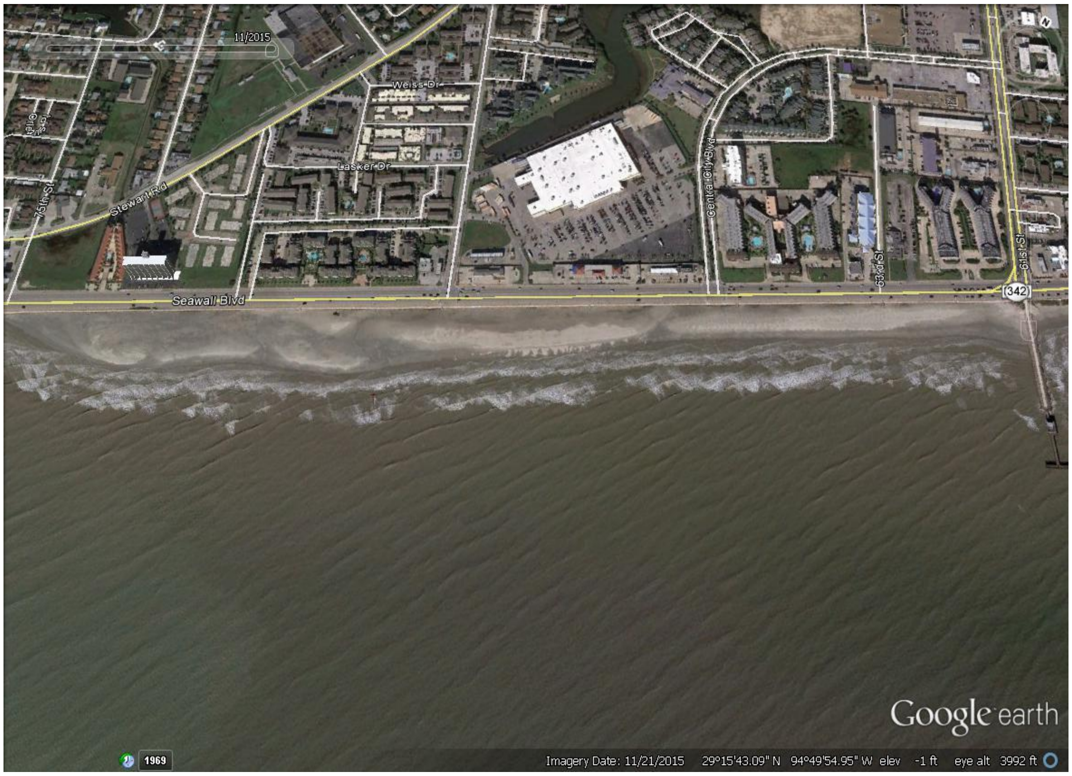

Figure 9 “Galveston” Google Earth image
Notes: This Google Earth image shows the new beach added in the Galveston beach nourishment project in 2015. Dredge material was added between 61st and 75th street, creating a new beach about 4,900 feet in length, and on average 230 feet wide.

APPENDIX B

TABLES

Table 1 Summary Statistics for parcel data – Galveston, Texas; 2000-2014. Obtained from CoreLogic Inc.

Variable	Description	Mean	Std.Dev.	Min	Max
l_price	Real 2014 property prices, log	11.78708	0.7331371	7.392087	16.35954
age	Age=sales year-built year	39.29878	22.03795	0	168
age_sq	Age squared	2030.024	2428.556	0	28224
acres	Total lot acres	0.1711083	0.3375012	0.0199	12.879
acres_sq	Acres squared	0.1431754	3.092128	0.000396	165.8686
buildingsq~t	Total building square footage	1730.418	845.8846	240	25495
building_sq	building square footage squared	3709805	7351891	57600	6.50E+08
totalbaths	Total number of bathrooms	1.803649	0.8720314	1	10
bath_sq	Bathrooms squared	4.013524	4.620279	1	100
garage_d	Garage=1, otherwise=0	0.7940347	0.4044225	0	1
pool_d	Pool=1, otherwise=o	0.0744381	0.2624937	0	1
foundation_p	Pier and Stone=1, otherwise=0	0.2300658	0.4208927	0	1
fireplace	Fireplace=1., otherwise=0	0.2562174	0.436562	0	1
aircondition	Air-conditioning=1, otherwise=0	0.7154944	0.4511979	0	1
heat_central	Central heating=1. otherwise=0	0.7124177	0.4526546	0	1
storiesnum~r	Total number of stories	1.274549	0.432767	1	3
quality	Excellent or good=1, otherwise=0	0.3144176	0.4643033	0	1
distance_w~t	Distance of parcel from beach*width of beach	402138.9	427011	0	3107863
BeachWidth~t	Width of beach in feet	124.6214	125.671	0	702
DuneWidthF~t	Width of dunes in feet	21.55241	43.93294	0	303
ShorelineC~f	Distance from shoreline to continental shelf	131384.8	13792.34	74371.68	142702.8
r_price	Real 2014 property prices	173363.3	222110.7	1623.09	1.27E+07

* p<0.1; ** p<0.05; *** p<0.01; Robust standard errors clustered by census block presented in parenthesis.

Table 2 OLS Model Results

	(1)	(2)
age	-0.00435***	-0.00407***
	(0.00116)	(0.00117)
age_sq	0.00004***	0.00003***
	(0.00001)	(0.00001)
acres	0.17953**	0.17300**
	(0.07961)	(0.07793)
acres_sq	-0.01696**	-0.01632**
	(0.00708)	(0.00689)
buildingsquarefeet	0.00040***	0.00040***
	(0.00002)	(0.00002)
building_sq	-0.00000***	-0.00000***
	(0.00000)	(0.00000)
totalbaths	0.19765***	0.19738***
	(0.02257)	(0.02262)
bath_sq	-0.02038***	-0.02039***
	(0.00429)	(0.00430)
garage_d	0.22219***	0.22141***
	(0.01825)	(0.01836)
pool_d	0.09103***	0.09149***
	(0.02412)	(0.02392)
foundation_p	-0.00393	-0.00213
	(0.01663)	(0.01665)
fireplace	0.15835***	0.15898***
	(0.01749)	(0.01757)
aircondition	0.11285***	0.11333***
	(0.02988)	(0.03005)
heat_central	0.09316***	0.09315***
	(0.02949)	(0.02966)
storiesnumber	0.06697***	0.06793***
	(0.02404)	(0.02389)
quality	0.17771***	0.17808***
	(0.01483)	(0.01479)
distance_width_alt*1000	-0.00024***	-0.00024***
	(0.00000)	(0.00000)
BeachWidth_alt	0.00065***	0.00075***
	(0.00012)	(0.00010)
DuneWidthFeet	0.00271***	0.00278***
	(0.00026)	(0.00026)
DistanceParcelBeach	-0.00001	
	(0.00001)	
_cons	10.29161***	10.26194***
	(0.07348)	(0.07070)
R^2	0.60	0.60
N	11,701	11,701

* p<0.1; ** p<0.05; *** p<0.01; Robust standard errors clustered by census block presented in parenthesis.

Table 3 IV Model First Stage Results

	Coeff.	St.error
age	0.8943441***	(0.23213)
age_sq	-0.0033805**	(0.00167)
acres	-37.15067***	(10.15601)
acres_sq	3.539024***	(1.01870)
buildingsquarefeet	-0.0062328*	(0.00366)
building_sq	0.000000374**	(0.00000)
totalbaths	4.993072	(4.69930)
bath_sq	-0.3527803	(0.68355)
garage_d	-16.73793***	(4.27799)
pool_d	-9.991165**	(3.91683)
foundation_p	14.48375***	(3.84470)
fireplace	-9.414723***	(3.25368)
aircondition	-1.740031	(7.15021)
heat_central	-3.452167	(6.95776)
storiesnumber	19.09147***	(4.79376)
quality	10.97081***	(3.72611)
distance_width_alt	0.0002083***	(0.00001)
DuneWidthFeet	0.1539433	(0.12102)
ShorelineContShelf	-0.0010735***	(0.00027)
_cons	170.2611***	(39.62378)
F-statistics	15.63***	
Centered R-sqaure	0.5836	
Uncentered R-squared	0.7901	
Dependent variable= BeachWidth_alt		

* p<0.1; ** p<0.05; *** p<0.01; Robust standard errors clustered by census block presented in parenthesis.

Table 4 IV Model Results

	(1)	(2)
BeachWidth_alt	0.00972*	0.00470***
	(0.00516)	(0.00151)
age	0.00122	-0.00662***
	(0.00343)	(0.00205)
age_sq	-0.00000	0.00004***
	(0.00002)	(0.00001)
acres	0.13693*	0.29015***
	(0.08036)	(0.10408)
acres_sq	-0.01283*	-0.02800***
	(0.00710)	(0.00991)
buildingsquarefeet	0.00047***	0.00044***
	(0.00004)	(0.00003)
building_sq	-0.00000***	-0.00000***
	(0.00000)	(0.00000)
totalbaths	0.15761***	0.17689***
	(0.05114)	(0.03320)
bath_sq	-0.01854**	-0.01896***
	(0.00799)	(0.00592)
garage_d	0.29632***	0.28805***
	(0.05223)	(0.03325)
pool_d	0.17186***	0.13494***
	(0.06307)	(0.03488)
foundation_p	-0.02247	-0.05451*
	(0.03182)	(0.02952)
fireplace	0.22638***	0.19004***
	(0.05415)	(0.02662)
aircondition	0.12462*	0.11041**
	(0.06573)	(0.04292)
heat_central	0.13035**	0.11813***
	(0.06620)	(0.04241)
storiesnumber	-0.03309	-0.01993
	(0.06193)	(0.04502)
quality	0.11388**	0.12730***
	(0.04479)	(0.02741)
distance_width_alt*100000	-0.10*	-0.10***
	(0.00000)	(0.00000)
DuneWidthFeet	0.00315***	0.00133*
	(0.00083)	(0.00080)
DistanceParcelBeach	0.00021*	
	(0.00012)	
Year FE	Y	Y
_cons	9.07804***	10.11625***
	(0.68848)	(0.11434)
R^2	-0.07	0.41
N	11,701	11,701

* p<0.1; ** p<0.05; *** p<0.01; Robust standard errors clustered by census block presented in parenthesis.

Table 5 IV Sea Wall protected sample Model Results

	(1)	(2)
BeachWidth_alt	0.00205***	0.00173***
	(0.00032)	(0.00021)
age	-0.00395***	-0.00466***
	(0.00133)	(0.00138)
age_sq	0.00004***	0.00004***
	(0.00001)	(0.00001)
acres	1.19469***	1.28059***
	(0.20479)	(0.20033)
acres_sq	-0.47967***	-0.50553***
	(0.14366)	(0.14301)
buildingsquarefeet	0.00053***	0.00053***
	(0.00004)	(0.00004)
building_sq	-0.00000***	-0.00000***
	(0.00000)	(0.00000)
totalbaths	0.14770***	0.14899***
	(0.02176)	(0.02157)
bath_sq	-0.01290***	-0.01302***
	(0.00367)	(0.00365)
garage_d	0.19416***	0.19493***
	(0.01808)	(0.01788)
pool_d	0.09416***	0.09059***
	(0.02708)	(0.02729)
foundation_p	0.01833	0.01389
	(0.01698)	(0.01672)
fireplace	0.11917***	0.11612***
	(0.01970)	(0.01986)
aircondition	0.10420***	0.10328***
	(0.03256)	(0.03161)
heat_central	0.07683**	0.07704**
	(0.03204)	(0.03109)
storiesnumber	0.06288***	0.06458***
	(0.02360)	(0.02370)
quality	0.14858***	0.14943***
	(0.01855)	(0.01864)
distance_width_alt*1000	-0.0005***	-0.0005***
	(0.00000)	(0.00000)
DuneWidthFeet	0.00531***	0.00555***
	(0.00189)	(0.00197)
DistanceParcelBeach	0.00002**	
	(0.00001)	
_cons	9.99549***	10.07052***
	(0.09288)	(0.08804)
Year FE	Y	Y
R^2	0.59	0.59
N	9,374	9,374

* p<0.1; ** p<0.05; *** p<0.01; Robust standard errors clustered by census block presented in parenthesis.

Table 6 The increase in property values expected from a creation of both a 124 foot and 200 foot wide beach.

Estimated Increase of Property Value Associated With Beach Width

Distance from Beach (Feet)	Increase from 0-124 (Feet)	Increase from 0-200 (Feet)
Beachfront	$88,175.40	$172,702.30
528 feet	$75,128.80	$143,470.30
1320 feet	$57,144.80	$105,173.40
2640 feet	$30,951.30	$53,724.80
3960 feet	$8,841.10	$14,527.30
4400 feet	$2,265.40	$3,657.90

Table 7 The estimated increase in property taxes associated with an increase in property values from creation of a 124 foot and 200 foot wide beach.

Increase in Property Taxes Associated with Increase in Property Values from Increase in Beach Width		
Distance from Beach (Feet)	Increase from 0-124 Feet	Increase from 0-200 Feet
Beachfront	$484.96	$949.86
528 feet	$413.21	$789.09
1320 feet	$314.30	$578.45
2640 feet	$170.23	$295.49
3960 feet	$48.63	$79.90
4400 feet	$12.46	$20.12