Flood Hazards, Insurance Rates, and Amenities: Evidence from the Coastal Housing Market

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Abstract

This study employs the hedonic property price method to examine the effects of flood hazard on coastal property values. We utilize Geographic Information System (GIS) data on flood zones and residential property sales from mainland Carteret County, North Carolina. The analysis highlights the high degree of correlation between coastal hazard and amenity levels—an aspect of the market that can confound attempts to measure risk or amenity tradeoffs with housing sales data. Our results indicate that location within a floodplain lowers property value and that the price differential for higher flood risk areas is significantly larger than that of lower risk areas. Price differentials for flood risk are roughly equivalent to the capitalized value of flood insurance premiums. Given the evidence that flood insurance coverage is far from widespread among coastal households, we construe this result as supporting the proposition that flood zone designation and insurance premiums convey risk information to potential buyers in the coastal housing market.

Keywords: coastal hazards, flood insurance, hedonic prices, spatial regression

JEL Classifications: D12, G22, Q24, R21

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1. INTRODUCTION

Hedonic property models provide an intuitive analytical tool for examining the effects of housing attributes and spatially delineated characteristics on housing prices. Rosen (1974) formalized the relationship between the equilibrium price schedule, supplier technology, and household preferences in a competitive market. From the perspective of the household, marginal implicit prices can be interpreted as marginal willingness to pay for housing attributes. In their test of expected utility theory, Brookshire et al. (1985) were the first (to our knowledge) to consider spatially delineated risk factors in the context of the hedonic model, and relate these to household tradeoffs. Their analysis suggests that California households are aware of spatial differences in earthquake risk, primarily due to special risk assessments conducted by government authorities in conjunction with disclosure requirements, and that the market capitalizes this risk, discounting properties in the high-risk area.

A number of hedonic property studies of hazards followed in the environment and risk literature, focusing on earthquake/volcanic hazards (Bernknopf, Brookshire, and Thayer 1990; Beron et al. 1997), flood hazards (MacDonald, Murdoch, and White 1987; MacDonald, et al. 1990; Bin and Polasky 2004), hurricane hazards (Hallstrom and Smith 2005), hazardous waste and Superfund sites (Clark and Allison 1999; Gayer, Hamilton, and Viscusi 2000; McClusky and Rausser 2001), erosion hazards (Kriesel, Randall, and Lichtkoppler 1993; Landry, Keeler, and Kriesel 2003), wind hazards (Simmons, Kruse, and Smith 2002), and wildfire hazards (Donovan, Champ, and Butry 2006). Some of these papers make use of cross-sectional variation in risk-related attributes of properties to identify risk tradeoffs (MacDonald, Murdoch, and White 1987;

MacDonald, et al. 1990; Kriesel, Randall, and Lichtkoppler 1993; Landry, Keeler, and Kriesel 2003; Simmons, Kruse, and Smith 2002), others make use of variation in government- or media-provided risk information over time (Brookshire et al. 1985; Bernknopf, Brookshire, and Thayer 1990; Clark and Allison 1999; Gayer, Hamilton, and Viscusi 2000; McClusky and Rausser 2001; Donovan, Champ, and Butry 2006), while still others utilize quasi-random, natural experiments to induce an exogenous change in risk information (Beron et al. 1997; Bin and Polasky 2004; Hallstrom and Smith 2005).[1]

It has recently been acknowledged that the level of risk associated with a property may be correlated with spatial amenity (or disamenity) levels. In their study of water pollution, Leggett and Bockstael (2000) note that pollution levels will tend to correlate with spatial disamenities, such as noise, odor, and unsightliness, associated with pollution emitters. As such, the effect of pollution may be overestimated unless other aesthetic disamenities are controlled. They use Euclidean distance from various emitters, proportional measures of surrounding land uses, and take advantage of an irregular coastline that creates considerable variation in pollution levels to break the correlation between pollution and emitter effects. Gayer, Hamilton, and Viscusi (2000) encounter a similar problem in their study of hazardous waste sites. They too use Euclidean distance to control for visual disamenities independent of perceived health risk. In both of these papers, risks attributable to man-made hazards are correlated with other disamenities associated with the source of such hazards.

In other settings, natural hazards can be correlated with spatial amenities. Donovan, Champ, and Butry (2006) examine wildfire risk, which is partially determined by housing and spatial attributes that households may value as amenities. Their results suggest that an education

[1] Other applications of the hedonic technique to risk include wage models (see for example Smith et al. (2004)) and automobile purchase (see for example Andersson (2005)). We focus herein on the hedonic property model.

campaign on wildfire hazards is effective in altering the hedonic price of risk-enhancing amenities—whereas wood roofing initially has a positive effect on housing prices and wood siding has no effect, the effect of both attributes becomes negative after an education campaign highlights the wildfire risk inherent in these housing attributes. In the coastal zone, environmental risks, including flood, erosion, and wind hazard, are highly correlated with spatial amenities, such as proximity to water, water-frontage, and view. Not able to break the correlation between coastal amenities and risk, Hallstrom and Smith (2005) use the occurrence of a nearby hurricane to represent a change in information on hazards. The positive correlation between risk and spatial amenities can bias estimates of risk tradeoffs if amenities are not controlled. Likewise, the estimated value of amenities could be biased if risk factors are not accounted. Other property settings in which correlation between risk and amenities might be found include hillside properties with views of cityscapes or natural areas, but exposed to landslide risk, and properties along rivers and streams that are exposed to risk of flooding.

In this paper, we examine flood hazards in the coastal housing market of Carteret County, North Carolina. We consider the mainland and the barrier islands of Carteret County as separate housing markets because they vary in a number of important ways. First of all, buyers and sellers in the two markets can be very different. Barrier-island properties are often held by retirees and households that use the properties as vacation homes, sometimes renting the properties to others. As such, the local labor market has much less influence on the types of agents that engage in trade of real estate, and thus the extent of the market, on barrier islands. Owners of barrier-island property may not consider the adjacent mainland as providing potential substitutes. Barrier island properties provide direct access to beach amenities and tend to be much more valuable than mainland parcels. Secondly, barrier island properties are exposed to more diverse risk factors, such as direct hurricane forces and coastal beach erosion. Mainland properties adjacent to barrier islands are not generally susceptible to erosion hazard and are sheltered from high velocity wave action.

We use a spatial autoregressive model to control for unobservable characteristics of nearby properties, and investigate the effects of differential flood risks on property values, controlling for amenities associated with proximity to water. We differentiate between the 100-year floodplain (i.e., a 1.0 % annual chance of flooding) and the 500-year floodplain (i.e., a 0.2% annual chance of flooding), and show that implicit prices for flood classification are sensitive to the treatment of coastal amenities. Without controlling for amenities, floodplain location appears to have no effect on housing value. When amenities are included, amenity and risk variables exhibit the expected sign and are statistically significant. Results suggest that location within a floodplain lowers the average property's value by 7.3 percent or $11,598. Furthermore, we find that the price discount for location within a higher flood risk area is significantly larger than the price discount for location within a lower risk area. Location within a 100-year floodplain lowers the average property's value by 7.8 percent ($12,325) while location within a 500-year floodplain lowers average property value by 6.2 percent ($9,849). We calculate the flood insurance premiums for the different flood zones and find that the capitalized values of the insurance premiums are comparable with the sales price differentials.

2. A THEORTICAL FRAMEWORK

Hedonic property models have been used extensively in environmental and natural resource economics as a non-market valuation technique. The basic idea underlying the model is that differential property prices reflect the way households value different bundles of property characteristics. Residential properties are composite goods that contain different amounts of a variety of attributes, and observing how property values change as the level of various attributes change, such as flood hazard, *ceteris paribus*, provides a way of estimating the incremental value of these attributes to property owners. The observed discount on property in an area with high flood risk thus reflects households' willingness to pay to avoid such risk. Multivariate statistics are used to make the *ceteris paribus*, or "all else being equal", assumption operational. The hedonic property price method has an advantage over other assessment techniques in that it makes use of actual market prices to recover value estimates for various non-market attributes. Palmquist (2004) provides a useful summary of the theoretical aspects of hedonic price models.

The hedonic price function is typically represented as:

$$Y = Y(s, n, e, r), \qquad [1]$$

where Y is the sales price, which is a function of structural characteristics, s, neighborhood characteristics, n, environmental characteristics, e, and risk characteristics, r. Assuming that $Y(\bullet)$ is continuously differentiable, the first derivative of [1] with respect to any continuous attributes produces an estimate of the representative households' marginal willingness to pay for an additional unit of that attribute (Rosen 1974). Let household utility be represented by $U(s, n, e, q)$, where q is a composite commodity that serves as numeraire. We assume U is bounded, increasing, and strictly concave in all arguments. To incorporate risk, we build upon the expected utility model of Brookshire et al. (1985).

Survey research of Chivers and Flores (2002) suggests that the overwhelming majority of households living in flood prone areas of Colorado were unaware of the risk classification and flood insurance rates at the time they submitted their bid for the property. They view this evidence as supporting hedonic property results that find no influence of risk on housing price

(Tobin and Montz 1997; Chivers 2001)—it could simply be that households are unaware when forming their bid price. We consider the likelihood of being unaware of the cost of flood insurance to be fairly high for our sample of coastal properties, as there are no terms for disclosure of flood insurance cost, and the flood insurance policy is administered separately from the Principle, Interest, Taxes, and Insurance (PITI) payment of the mortgage contract. However, we consider highly unlikely that households in our sample are unaware of flood risk. Flood zone designation is listed as part of property disclosure, is readily available from various sources, and the risk of flood is arguably more recognizable in the low-lying, hurricane prone coastal zone of North Carolina. As such, we consider the household's expected utility function:

$$\begin{aligned} V = {} & p(r) \cdot U^{L}[s, n, e, m^{L} - \alpha \cdot Y(s, n, e, r)] \\ & + (1 - p(r)) \cdot U^{NL}[s, n, e, m^{NL} - \alpha \cdot Y(s, n, e, r)] \end{aligned} \qquad [2]$$

where $p(r)$ is the subjective probability of a damage-producing flood event; the utility function is state dependent across loss (superscript L) and no-loss (superscript NL) states; m^L represents expected income in the loss state—income remaining for consumption of the numeraire, including any insurance settlement net of insurance payments, loss from the flood event, and deductible (assuming they hold flood insurance); m^{NL} represents expected income in the no-loss state, and α is a parameter that converts sales price to an annual payment. Flood zones are defined by recurrence intervals (e.g. 100-year flood zone, or 1% chance per annum) such that we feel subjective assessment of flooding probability should roughly correspond with the objective assessment.

Under competitive market conditions, buyers take the hedonic price schedule $Y(\bullet)$ as given and optimize expected utility through the choice of housing characteristics, with residual income leftover for consumption of a composite commodity. Assuming continuous housing attributes and risk measures, the following first order conditions characterize the optimal choice of attributes:

$$a: \qquad Y_a = \frac{p \cdot U_a^L + (1-p) \cdot U_a^{NL}}{\alpha[p \cdot U_m^L + (1-p) \cdot U_m^{NL}]} \qquad [3]$$

$$r: \qquad Y_r = \frac{p_r (U^L - U^{NL})}{\alpha[p \cdot U_m^L + (1-p) \cdot U_m^{NL}]} \qquad [4]$$

where *a* = *s*, *n*, *e*, and subscripts on *U*, *Y*, and *p* denote partial derivatives. Equation [3] indicates that the marginal implicit hedonic price for amenities reflects the expected amenity value. Equation [4] indicates that the marginal implicit price for risk attributes reflects marginal probability of the incremental utility difference across states, $p_r (U^L - U^{NL})$. Dividing by the expected marginal utility of income, $p \cdot U_m^L + (1-p)U_m^{NL}$, produces a measure of marginal willingness to pay. We use the framework of [2] and the results in [3] and [4] to guide our formulation of the hedonic price model and interpretation of the parameter estimates.

3. STUDY AREA AND DATA

Data for this study come from Carteret County, located on the coast of the Atlantic Ocean in eastern North Carolina. It has a total population of 59,383. The largest town in the county, Morehead City, has a population of 7,691. Given its coastal location, the county has substantial access to water, including the Atlantic Ocean, the Pamlico Sound, the Inter-coastal Waterway, back-barrier lagoons, rivers such as the White Oak and Newport, and numerous streams, creeks and wetlands. The land in Carteret County is relatively flat and low-lying, and much of the area is prone to flooding. The map of Carteret County shown in figure 1 provides the geographic distribution of the floodplains. As shown in figure 1, the 100-year floodplains are common along the coastline, rivers and streams, while the 500-year floodplains tend to locate on other low-lying areas further inland.

After a relatively calm period of hurricane activity, North Carolina was exposed to six significant storms in the 1990s (Gordon in 1994, Bertha in 1996, Fran in 1996, Bonnie in 1998, Dennis in 1999, and Floyd in 1999). Thus, we feel that sellers and most potential buyers are cognizant of the types of hurricane risk inherent in locating in coastal North Carolina. Hurricane Isabel made landfall September 2003 at Drum Inlet along the Outer Banks. While Isabel caused major flooding and loss of power in the mid-Atlantic region, the impacts on Carteret County were relatively minor. Hurricane Charley did affect coastal North Carolina in August of 2004, but by the time it arrived it had been downgraded to a tropical storm (National Oceanic & Atmospheric Administration – National Hurricane Center 2005). Since we believe that buyers and sellers were aware of the degree of hurricane risk in the area, we do not expect that hurricane events during the period of our analysis induced any major changes in information or household perceptions.

Multiple GIS-based data sets are utilized for this study: property parcel data from Carteret County Tax Office; digital flood maps and other GIS layers from North Carolina Floodplain Mapping Program; and county/coastline boundary data from North Carolina Center for Geographic Information and Analysis. Data from these sources are merged so that flood hazard and coastal amenities for each property are combined with the typical structural and neighborhood attributes.

Carteret County Tax Office maintains detailed sales records for all properties in the county. Carteret County is comprised of mainland plus coastal barrier islands. The barrier islands are primarily a vacation and resort area with many rental properties. We maintain that the housing market on the barrier islands is quite different from that of the mainland. Property sales data from the barrier islands are excluded in this study. This study utilizes a total of 3,106 residential property sales records from September 2000 to September 2004. Sales prices were inflation-adjusted using a Consumer Price Index to report figures in September 2004 dollars. The average home sales price in the data set was $163,911. The data also include a series of structural attributes such as the number of bathrooms, age of the house, square footage of the house, the lot size, and whether a house is sold within a year of construction (which we construe as new housing). The homes are on average 24 years old and have about 1,633 total square feet. About 16% of the properties are classified as new (sold within a year from the date built).

Digital flood maps from the North Carolina Floodplain Mapping Program are used to identify properties within floodplains. Floodplain maps provide the location and extent of floodplains in the county. We denote two major categories of floodplains based upon the recurrence interval. A 100-year floodplain (or A-zone) corresponds to an area that would flood in a 100-year flood event. Due to the relatively high risk of flooding in this area, mandatory flood insurance purchase is required for homeowners who purchase homes in this zone and finance that purchase through federally regulated lenders. About 13% of the homes sold during the time horizon of our analysis were located in the in the A-flood zone.[2] A 500-year floodplain (or X-zone) corresponds to an area outside the 100-year floodplain, but associated with moderate flood hazard. The 500-year floodplain represents a lower level of flood risk, and thus the

[2] Generally speaking, some properties in the 100-year floodplains are also located in the Special Flood Hazard Area, also known as the V-zone, in which homes are subject to additional vulnerability associated with high velocity wave action (and thus higher insurance rates). This type of flood zone is common in the coastal communities adjacent to ocean beaches (i.e. primarily barrier islands on the East Coast). Given our focus on mainland housing market, we have only 6 houses (less than 0.2% of the total observations) located in this special flood zone. Analysis of Special Flood Hazard Areas is thus beyond the scope of this study.

insurance premiums tend to be lower for properties within this area. About 4% of the homes in our data set locate within the X-flood zone.

By law, a property is considered "in a flood zone" if any part of the structure falls within a floodplain. Since our GIS data contains only an outline of the land parcel (i.e. not the footprint of the structure), we define presence within a flood zone as the center of the parcel being located within a floodplain. While this definition does create the potential for error, in the overwhelming majority of cases location in reference to the floodplain was unambiguous. In addition, a binary indicator—post-FIRM—identifies properties that are constructed on or after the effective date of the initial Flood Insurance Rate Map (FIRM) for the community (or after December 31, 1974, whichever is later). Post-FIRM properties within a floodplain are likely to have higher elevation and exhibit other building standards designed to make them flood resistant, but are also subject to more expensive flood insurance premiums than otherwise equivalent pre-FIRM properties. Under the assumption that most pre-FIRM homes have not been substantially improved or repaired since initial construction, this binary variable will indicate whether post-FIRM properties are valued differently from pre-FIRM properties, all else being equal.

Flood insurance premiums are calculated in accord with the National Flood Insurance Program (NFIP) Flood Insurance Manual (May 2004) guidelines. The current version of the manual establishes a rate structure that depends on the recurrence interval (100-year or 500-year return interval), the date of construction, and presence of a Community Rating System (CRS). The NFIP was developed with the goal of meeting two challenges: to contain the rising cost of damage caused by disasters and to provide economically feasible relief to victims that would fuel recovery (Pasterick 1998). In 1968, Congress passed the National Flood Insurance Act which created the NFIP. Prior to this legislation, the federal government routinely paid large sums for disaster relief after floods. Under current provisions, NFIP insurance is available only in communities with approved community floodplain management plans, which currently number about 20,000 communities in the U.S. The National Flood Insurance Program (NFIP) provides a maximum flood coverage limit of $250,000 on single-family homes.

Amenities such as the proximity to coastal water (i.e., ocean, sound, and inter-coastal waterways), water frontage, and boat access are highly valued in the coastal housing market. In order to account for these amenities, we measure the distance to nearest coastal water for each residential property using GIS data that delineate the boundary of the sound, barrier islands, and coastal waterways. The distance is measured as the Euclidean distance in feet from the centroid of each property to the nearest coastal water. The average distance to nearest coastal water is slightly less than one mile in our data set (4,882 feet). A binary indicator for first row from coastal water is created to proxy for water frontage and access. About 10% of homes sold during the period of our analysis have water frontage. While we would like to include a measure of view amenity, data limitations permitted us from constructing a view proxy.[3] Nonetheless, we feel that view will be highly correlated with distance from the water, so that the effect of distance will likely reflect the effect of view amenities. We also control for neighborhood characteristics using distance to nearest central business district (downtown Morehead City), nearest highway, and nearest park, forest, or game land. We control for heterogeneity across townships using a set of dummy variables representing the fifteen townships in the county. Table 1 provides the definition and description of the variables used in this study. Summary statistics are presented in table 2.

[3] Constructing a view variable within GIS requires detailed data on the location and physical dimensions of coastal structures. Unfortunately, such data was not available for the mainland of Carteret County.

4. EMPIRICAL ANALYSIS

There has been a tremendous increase in the availability of spatial data and spatial analysis functionality in recent years. Considerable attention has been given to examining spatial dependence in estimated hedonic equations (Pace and Gilley 1997, Basu and Thibodeau 1998, Bowen, Mikelbank, and Prestegaard 2001, Patterson and Boyle 2002, Kim, Phipps, and Anselin 2003). Spatial dependence arises because residential properties sharing common features tend to cluster in space. Sales prices tend to cluster in space because houses in a neighborhood share similar location amenities (e.g. school district) or because they have similar structural characteristics due to similar timing of construction (e.g. alike design features). The existence of spatial dependence implies that a sample contains less information than an uncorrelated one, and that the loss of information should be acknowledged in estimation to properly carry out statistical inference. If the relevant spatial dependence is ignored in estimation of the hedonic price function, then the resulting estimates could be inefficient or even inconsistent, and any inference based the estimates may result in misleading conclusions (Anselin and Bera 1998).

The first step in this estimation process is to create a spatial weights matrix which defines a relevant "neighborhood set" for each observation. We use a contiguity matrix that identifies properties within .1 kilometers in a binary fashion. That is, $w_{ij} = 1$ when i and j are neighbors, and $w_{ij} = 0$ otherwise. The specification of the spatial weights matrix is based on our observations of the spatial extent that may share unobserved characteristics generating spatial dependence. We have experimented with different weight matrices, but the primary results are largely insensitive to different weight matrices.[4] Regression diagnostics based on Ordinary Least

[4] Anselin and Bera (1998) note that the spatial weights should be truly exogenous to the model and the range of dependence allowed by the structure of the weights matrix should be constrained to avoid identification problems. In spite of their lesser theoretical appeal, the alternative spatial weights based on social network, distance decay, and *k* nearest neighbors have been considered in the literature.

Squares (OLS) estimation and the Lagrange multiplier (LM) test statistics indicated that the spatial error model is the suggested alternative.[5] As a result, the following first-order spatial error hedonic model is considered:

$$\begin{aligned} lnY &= \alpha + \sum_i \beta_i x_i + \sum_j \gamma_j z_j + \sum_k \phi_k f_k + \varepsilon \\ \varepsilon &= \lambda W \varepsilon + u, \end{aligned} \quad [5]$$

where *ln Y* is the log of sales price, x_i is a dichotomous variable for the i^{th} housing attribute, z_j is a non-dichotomous variable for the j^{th} housing attribute, f_k is a dichotomous variable equal to one for location within the flood zone *k* and zero otherwise, λ is the spatial autoregressive coefficient, *W* is the spatial weights matrix, and *u* is a vector of independent and identically distributed random error terms. This model assumes that one or more omitted variables in the hedonic equation vary spatially, and thus the error terms are spatially autocorrelated. In this specification, the OLS estimator remains unbiased but is no longer efficient due to the nonspherical error covariance. Efficient estimators are obtained by utilizing the particular structure of the error covariance implied by the spatial process. The spatial autoregressive error models are estimated via maximum likelihood. The estimation is implemented within the GeoDa v.0.9.5-i (2004) environment in conjunction with ArcView GIS 3.3 extensions.

We use quadratic specifications for non-dichotomous structural variables such as age of the house and total structure square footage. The effect of these attributes on property values is assumed to decline as the level of the attributes increase. We also use the log of the distance to coastal water to capture the diminishing marginal returns for the proximity as the distance

[5] Spatial dependence can be also incorporated using a spatially lagged dependent variable model, which assumes that the spatially weighted sum of neighborhood housing prices enters as an explanatory variable in the hedonic price function. When both types of spatial dependence occur, the general model that includes both the spatial error and spatial lag terms can be considered. Failing to account for spatial lag dependence leads to biased and inconsistent parameter estimates, whereas failing to account for spatial error dependence leads to inefficiency.

increases. Distance to nearest central business district, nearest highway, and nearest park, forest, or game land are also log transformed. The primary results were robust across several alternative specifications, and the current specification provided the overall best fit.

In the following section, we report the estimation results and discuss the marginal effects of housing attributes on sales price. As suggested by Halvorsen and Palmquist (1980), the marginal effect for dummy variables is calculated by $Y \cdot \{\exp(\beta) - 1\}$, where Y is the sales price and β is the coefficient of a dummy variable. For distance related variables, which are log-transformed, the marginal effect is price times the distance coefficient divided by the distance. All marginal effects are evaluated at the observed mean values.

5. ESTIMATION RESULTS

The estimation results of spatial autoregressive error models are reported in table 3. We estimate four different models based on the flood hazard variables and the inclusion of coastal amenity variables. In models [1] and [2], we do not differentiate between the levels of flood risk (i.e. 100-year floodplain vs. 500-year floodplain). The flood hazard variable represents the location within any type of floodplain. Model [1] excludes the coastal amenity variables (distance to coastal water and coastal waterfront indicator) while model [2] controls for these variables. In models [3] and [4] we differentiate between the high flood risk areas (100-year floodplains) and the low flood risk areas (500-year floodplains). Similarly, model [3] excludes the coastal amenity variables while model [4] controls for these variables. Most structural and neighborhood characteristics are statistically significant and have expected signs that are stable across specifications.

Knowing that proximity to water is highly desirable in coastal housing markets, model [1], which does not include amenity levels, is something of a "straw man". However, considering these parameter estimates juxtaposed to a more complete specification illustrates how an incomplete accounting of risks and amenities can lead to biased inferences. The flood risk variable in model [1] has the expected negative sign, but the effect is not statistically significant. The insignificant coefficient on the flood risk variable likely reflects the compounded effects of coastal amenities (proximity to coastal waterways and water access) and flood hazards. Such correlation, if present, would attenuate the coefficient on flood risk and increase the estimated variance of the parameter due to additional noise in the data. After controlling for the distance to coastal water and the coastal water frontage in model [2], the flood variable has a negative sign and becomes significant at any conventional level. The difference in the log-likelihood functions between model [1] and model [2] is large enough to conclude that the coastal amenity measures are important in the hedonic function specification. The result suggests that location within a floodplain lowers the average property's value by 7.3%. The marginal effect estimate suggests that location in a floodplain results in an $11,598 discount evaluated at the mean property value ($163,911).

The coefficient on distance to coastal water has a statistically significant and negative sign, implying that proximity to coastal water is desirable. As expected, coastal water frontage is also highly valued. The floodplains in a coastal setting are likely to be found adjacent to water, and in some areas almost all waterfront properties fall in a flood zone. Our data suggest that coastal amenities such as proximity to coastal water or water frontage are highly correlated with coastal hazard risks, and omitting coastal amenities in hedonic models may result in biased estimates of the effects of hazards on property values (and vice versa). However, this correlation is not perfect, and thus accounting for amenities allows for identification of the differential effects. After controlling for coastal amenities, our findings with regard to flood hazard are consistent with previous findings in the literature that have evaluated the effect of flood hazard on housing values in non-coastal settings (Shilling, Benjamin, and Sirmans 1985; MacDonald, Murdoch, and White 1987; Donnelly 1989; MacDonald, White, Taube, and Huth 1990; Harrison, Smersh, and Schwartz 2001; Bin and Polasky 2004). A common finding in these studies is that location within a floodplain lowers property values from 3% to 12%.

Models [3] and [4] provide the estimation results for distinguishing flood risks between location within a 100-year floodplain and location within a 500-year floodplain. Given a chi square distribution with two degrees of freedom, the likelihood ratio test statistic is significant at any conventional level of significance. The result suggests that exclusion of the coastal amenity measures may lead to the biased conclusions on the valuation of risk in a coastal setting. Most coefficient signs are identical to those of models [1] and [2]. In model [3] where we do not control for coastal amenities, the variable for the location within a 500-year floodplain has a significant, negative sign while the location within a 100-year floodplain is insignificant. However, after controlling for the coastal amenities in model [4], both flood risk variables become significant and have negative signs. As seen in figure 1, the 500-year floodplains are usually located in low-lying inland areas and have little to do with coastal water. Hence, the 500-year flood risk variable is less affected by the omission of coastal amenity measures than the 100-year flood risk variable. Results indicate that the price discount from locating within a higher flood risk area is significantly larger than the price discount from a lower risk area. The location within a 100-year floodplain lowers the property values by 7.8% while the location within a 500-year floodplain lowers the property values by 6.2%. The average price discount for being in a flood zone is estimated to be $12,325 and $9,849 for the 100-year and 500-year flood risk areas, respectively.

We calculate flood insurance premiums and compare capitalized insurance premiums with sales price differentials in table 4. We use three housing values: low ($75,000), average ($150,000), and high ($225,000). Reported insurance premiums are based on the NFIP insurance rates in May 2004. Insurance premiums depend on the value of insured structure and contents, deductibles, as well as the type of flood zone. Annual flood insurance premiums for each type of house are given in the second column of table 4. The annual insurance premiums are discounted in perpetuity using discount rates of four percent, eight percent, and twelve percent. For an "average" valued house, assuming an eight percent discount rate, the capitalized premium value of flood insurance is $10,500 and $7,588 for the location within a 100-year and 500-year floodplain, respectively. For all property price ranges, the sales price differential between inside and outside these flood zones is quite comparable to the capitalized value of the flood insurance. The sales price differentials are within the range of the capitalized insurance premiums.

Increasing distance from the coastline has a strong negative impact on property values. Evaluated at the mean distance (4,882 feet), decreasing the distance to coastal water by 1,000 feet results in an increase in the property values by $3,540. Water frontage also commands a substantial premium and raises the property values by 31.3%. Evaluated at the sample mean, it provides a premium of $60,324 over an otherwise equivalent house. Milon, Gressel, and Mulkey (1984) estimated a large positive value from being close to the shore. They found that property values declined 36% in moving 500 feet from the Gulf of Mexico. Other studies have also found positive values for water proximity (Shabman and Bertelson 1979; Earnhart 2001).

Most structural housing characteristics are statistically significant and have expected signs across the models. The quadratic specifications seem to capture the diminishing marginal effects of house age and structure square footage. Evaluated at the average house value, the results indicate that house price increases by $93 per additional square foot. An additional year of age of a house lowers the estimated sales price by $865 evaluated at observed mean values. A new house sold within a year after construction is estimated to lower sales price by $9,491. After controlling for the age effect, a new house may be discounted for other reasons such as lack of landscaping at the time of sale. Our results indicate that post-FIRM properties are not valued differently from pre-FIRM properties. Coefficients for the distance to central business district, nearest highway, and nearest park, forest, or game land have expected signs but are statistically insignificant.

6. CONCLUDING REMARKS

This study examines the effects of flood hazards on coastal residential property values. In general, the estimation results indicate that the price of a residential property located within a floodplain is significantly lower than an otherwise similar house located outside the floodplain. On average, location within a floodplain lowers estimated sales value $11,598, which represents a 7.3 percent reduction of the average house sales price. In addition the data allow us to examine the marginal effects of different flood risks. The difference in the estimated discount between the high risk (100-year floodplain) and the low risk (500-year floodplain) designation is also statistically significant. In a model that differentiates between 100-year and 500-year return interval, the estimated discounts are $12,325 and $9,849, respectively.

We find that the estimated sales price differentials associated with location in a floodplain are consistent with the capitalized value of flood insurance for different levels of risk. Focusing on barrier islands, Kriesel and Landry (2004) estimate that only 49% of coastal households maintain flood insurance, despite mandatory purchase requirements for those households that hold a federally-backed mortgage. Assuming a similar proportion holds in the flood zone of the coastal mainland, the correspondence between implicit sales price differentials and capitalized insurance rates is noteworthy. That the average household may choose to forego formal flood insurance, but the market price of coastal properties reflects the capitalized insurance value suggests that flood zone designations do convey useful information about flood risk that affect buyer bidding behavior. It appears that the flood zone designation (and/or the associated insurance premium) may signal the differential flood risk associated with alternative locations regardless of whether flood insurance is purchased or not. This result is at odds with the findings of Chivers and Flores (2002); they find that homeowners in Boulder, Colorado were unaware of Special Flood Hazard designations when forming their bid price. This difference is not surprising, however, since we might expect residents of the coastal plain to be more cognizant of flood risk.

We find evidence of a strong positive correlation between coastal amenities and flood hazard. Our results suggest economists interested in analysis of amenities and/or hazards in coastal housing markets must be cognizant of the high degree of correlation between such attributes. Failure to control for both hazard risk and amenities will likely lead to biased results that inaccurately identify the sources of property value. Fortunately, there is sufficient variation in our data that we can separately identify the effects of amenities and hazards, however, in some coastal settings this may not be the case. Coastal barrier islands, for example, which exhibit complex and potentially confounding effects of amenities and multiple hazards present a challenging environment for hedonic modeling. We chose to exclude such properties from the analysis we report here.

We are exploring the possibility of employing GIS-based spatial indicators of property amenity values that are otherwise hard to quantify (Paterson and Boyle 2002). A *viewshed* is defined as the surface area visible from a vantage point in a three-dimensional space. A *viewshed* can be derived for each property by quantifying differing degrees of ocean or beach views while accounting for natural topography and built obstructions. Spatial accessibility can likewise be quantified as network travel distances (as opposed to straight-line distance) from properties to public beaches or beach access points. Analysis that uses the GIS-based variables described above may help to unravel the influence of amenity and risk on the value of highly desirable locations such as barrier island properties. This is the direction of future work.

The size of the population along the U.S. coast has expanded rapidly in the last several decades with growth rates that are more than double the national rate of population growth (Rappaport and Sachs 2003). One element driving such growth is the desire for access to unique coastal amenities. However, widespread coastal development has increased overall exposure to natural disasters, such as hurricanes, flooding, and erosion. This combination of growth and vulnerability has been seen as an explanation for the long term trend of rising insured disaster losses. With over half of the U.S. population now residing in coastal counties, the need for public policy analysis of hazards that affect these locations is compelling and urgent. As this research agenda develops, the spatial complexity of the coastal setting must be carefully considered in order to prescribe the appropriate policy instruments that sustain economic growth and manage the inherent hazard risks of coastal areas.

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Table 1. Definition and Description of the Variables

Variable	Description
PRICE	House sales price adjusted to September 2004 dollars
BATHRM	Number of bathrooms
AGE	Year house was built subtracted from 2004
SQFT	Total structure square footage
LOTSIZE	Total lot size measured in acres
NEWHOME	Dummy variable for new home (1 if sold within a year after built, 0 otherwise)
POSTFIRM	Dummy variable for post-FIRM properties (1 if post-FIRM, 0 otherwise)
FLOOD	Dummy variable for house within any floodplain (1 if inside, 0 otherwise)
FLOOD100	Dummy variable for house within a 100-yr floodplain (1 if inside, 0 otherwise)
FLOOD500	Dummy variable for house within a 500-yr floodplain (1 if inside, 0 otherwise)
COASTFRONT	Dummy variable for the first row from coastal water (1 if on, 0 otherwise)
COASTDIST	Distance in feet to the sound or intracoastal waterways
CBD	Distance in feet to downtown Morehead City
HIGHWAY	Distance in feet to nearest highway
PARK	Distance in feet to nearest park, forest, or game land
TOWN1	Dummy variable for a township (1 if Morehead, 0 otherwise)
TOWN2	Dummy variable for a township (1 if White Oak, 0 otherwise)
TOWN3	Dummy variable for a township (1 if Atlantic, 0 otherwise)
TOWN4	Dummy variable for a township (1 if Cedar Island, 0 otherwise)
TOWN5	Dummy variable for a township (1 if Davis, 0 otherwise)
TOWN6	Dummy variable for a township (1 if Harkers Island, 0 otherwise)
TOWN7	Dummy variable for a township (1 if Harlowe, 0 otherwise)
TOWN8	Dummy variable for a township (1 if Marshallberg, 0 otherwise)
TOWN9	Dummy variable for a township (1 if Merrimon, 0 otherwise)
TOWN10	Dummy variable for a township (1 if Newport, 0 otherwise)
TOWN11	Dummy variable for a township (1 if Sea Level, 0 otherwise)
TOWN12	Dummy variable for a township (1 if Smyrna, 0 otherwise)
TOWN13	Dummy variable for a township (1 if Stacy, 0 otherwise)
TOWN14	Dummy variable for a township (1 if Straits, 0 otherwise)
TOWN15	Dummy variable for a township (1 if Beaufort (County Seat), 0 otherwise)
YEAR00	Dummy variable for sales year (1 if sold in 2000, 0 otherwise)
YEAR01	Dummy variable for sales year (1 if sold in 2001, 0 otherwise)
YEAR02	Dummy variable for sales year (1 if sold in 2002, 0 otherwise)
YEAR03	Dummy variable for sales year (1 if sold in 2003, 0 otherwise)
YEAR04	Dummy variable for sales year (1 if sold in 2004, 0 otherwise)

Notes: A 100-year floodplain denotes an area of the 1% annual chance of flooding that is determined in the Flood Insurance Study. A 500-year floodplain includes an area outside the 1% annual chance floodplain, or an area of the 1% annual chance floodplain where average depths are less than 1 foot or where the contributing drainage area is less than 1 square mile.

Table 2. Summary Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
PRICE	163911.45	113578.35	10640.00	1150000.00
BATHRM	1.92	0.61	1.00	6.00
AGE	24.38	24.02	0.00	103.00
SQFT	1632.85	573.60	288.00	6108.00
LOTSIZE	0.67	1.46	0.03	46.30
NEWHOME	0.16	0.36	0.00	1.00
POSTFIRM	0.68	0.47	0.00	1.00
FLOOD	0.17	0.38	0.00	1.00
FLOOD100	0.13	0.33	0.00	1.00
FLOOD500	0.04	0.20	0.00	1.00
COASTFRONT	0.10	0.30	0.00	1.00
COASTDIST	4882.16	7671.97	2.11	36762.16
CBD	50561.76	35012.50	378.60	158071.29
HIGHWAY	6038.45	6662.40	54.50	62729.16
PARK	9952.99	7590.77	4.02	41962.51
TOWN1	0.38	0.48	0.00	1.00
TOWN2	0.21	0.40	0.00	1.00
TOWN3	0.01	0.10	0.00	1.00
TOWN4	4.2e-03	0.06	0.00	1.00
TOWN5	0.01	0.09	0.00	1.00
TOWN6	0.03	0.16	0.00	1.00
TOWN7	0.02	0.15	0.00	1.00
TOWN8	0.01	0.09	0.00	1.00
TOWN9	0.01	0.08	0.00	1.00
TOWN10	0.14	0.35	0.00	1.00
TOWN11	3.2e-03	0.06	0.00	1.00
TOWN12	0.01	0.09	0.00	1.00
TOWN13	2.9e-03	0.05	0.00	1.00
TOWN14	0.04	0.19	0.00	1.00
TOWN15	0.14	0.34	0.00	1.00
YEAR00	0.01	0.12	0.00	1.00
YEAR01	0.20	0.40	0.00	1.00
YEAR02	0.23	0.42	0.00	1.00
YEAR03	0.31	0.46	0.00	1.00
YEAR04	0.25	0.43	0.00	1.00

Note: Number of observations is 3106.

Table 3. Estimation Results – Spatial Autoregressive Error Models

	[1]			[2]			[3]			[4]		
	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value
INTERCEPT	10.725	0.196	0.000	11.337	0.218	0.000	10.728	0.196	0.000	11.337	0.218	0.000
BATHRM	0.095	0.046	0.038	0.109	0.050	0.029	0.099	0.046	0.031	0.108	0.050	0.030
$BATHRM^2$	-0.010	0.010	0.315	-0.011	0.011	0.293	-0.010	0.010	0.285	-0.011	0.011	0.298
AGE	-0.006	0.001	0.000	-0.010	0.002	0.000	-0.006	0.001	0.000	-0.010	0.002	0.000
AGE^2	5.9e-05	1.2e-05	0.000	9.4e-05	1.3e-05	0.000	6.0e-05	1.2e-05	0.000	9.4e-05	1.3e-05	0.000
SQFT	0.001	4.8e-05	0.000	0.001	5.0e-05	0.000	0.001	4.8e-05	0.000	0.001	5.0e-05	0.000
$SQFT^2$	-6.8e-05	1.2e-05	0.000	-1.1e-04	1.2e-05	0.000	-6.9e-05	1.2e-05	0.000	-1.1e-04	1.2e-05	0.000
LOTSIZE	0.027	0.007	0.000	0.030	0.008	0.000	0.027	0.007	0.000	0.030	0.008	0.000
$LOTSIZE^2$	-5.6e-05	2.4e-04	0.815	2.0e-04	2.6e-04	0.457	-4.1e-05	2.4e-04	0.864	1.9e-04	2.6e-04	0.465
NEWHOME	-0.053	0.021	0.012	-0.060	0.023	0.010	-0.054	0.021	0.011	-0.059	0.023	0.010
POSTFIRM	-0.030	0.029	0.303	-0.022	0.031	0.468	-0.031	0.029	0.284	-0.022	0.031	0.474
FLOOD	-0.028	0.020	0.170	-0.073	0.022	0.001						
FLOOD100							-0.010	0.023	0.654	-0.078	0.025	0.002
FLOOD500							-0.072	0.032	0.026	-0.062	0.035	0.074
COASTFRONT				0.313	0.030	0.000				0.314	0.030	0.000
ln(COASTDIST)				-0.106	0.009	0.000				-0.106	0.009	0.000
ln(CBD)	-0.008	0.013	0.501	-4.0e-04	0.014	0.976	-0.009	0.013	0.497	-3.8e-04	0.014	0.978
ln(HIGHWAY)	0.023	0.007	0.001	0.005	0.007	0.491	0.022	0.006	0.001	0.005	0.007	0.493
ln(PARK)	0.009	0.008	0.251	-0.001	0.008	0.899	0.009	0.008	0.253	-0.001	0.008	0.900
TOWN1	-0.268	0.067	0.000	-0.478	0.072	0.000	-0.272	0.067	0.000	-0.478	0.072	0.000
TOWN2	-0.082	0.099	0.409	-0.518	0.105	0.000	-0.096	0.100	0.334	-0.515	0.106	0.000
TOWN3	-0.308	0.069	0.000	-0.458	0.074	0.000	-0.326	0.070	0.000	-0.453	0.075	0.000
TOWN4	-0.027	0.046	0.552	-0.081	0.050	0.103	-0.034	0.046	0.464	-0.080	0.050	0.112
TOWN5	-0.188	0.043	0.000	-0.377	0.047	0.000	-0.189	0.043	0.000	-0.377	0.047	0.000
TOWN6	-0.235	0.068	0.001	-0.442	0.074	0.000	-0.253	0.069	0.000	-0.437	0.075	0.000

Table 3. Estimation Results – Spatial Autoregressive Error Models (Continued)

	[1]			[2]			[3]			[4]		
	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value	Coeff. Est.	Std. Error	p-value
TOWN7	-0.268	0.081	0.001	-0.366	0.086	0.000	-0.289	0.081	0.000	-0.361	0.087	0.000
TOWN8	-0.098	0.023	0.000	-0.115	0.024	0.000	-0.102	0.023	0.000	-0.114	0.024	0.000
TOWN9	-0.213	0.034	0.000	-0.013	0.042	0.748	-0.218	0.034	0.000	-0.012	0.042	0.783
TOWN10	-0.149	0.105	0.155	-0.509	0.114	0.000	-0.157	0.105	0.133	-0.508	0.114	0.000
TOWN11	-0.299	0.070	0.000	-0.489	0.074	0.000	-0.319	0.071	0.000	-0.484	0.075	0.000
TOWN12	-0.142	0.112	0.203	-0.528	0.121	0.000	-0.156	0.112	0.165	-0.525	0.121	0.000
TOWN13	-0.181	0.039	0.000	-0.268	0.041	0.000	-0.196	0.040	0.000	-0.264	0.042	0.000
TOWN14	-0.067	0.028	0.017	-0.120	0.030	0.000	-0.072	0.028	0.011	-0.119	0.031	0.000
YEAR01	0.020	0.051	0.701	0.020	0.056	0.717	0.018	0.051	0.722	0.021	0.056	0.712
YEAR02	0.044	0.051	0.391	0.067	0.055	0.223	0.043	0.051	0.401	0.068	0.055	0.221
YEAR03	0.067	0.051	0.190	0.096	0.055	0.081	0.066	0.051	0.194	0.096	0.055	0.080
YEAR04	0.068	0.051	0.188	0.111	0.055	0.044	0.066	0.051	0.197	0.112	0.055	0.044
LAMBDA	0.571	0.013	0.000	0.192	0.019	0.000	0.570	0.013	0.000	0.192	0.019	0.000
Observations			3106			3106			3106			3106
Log Likelihood			-1418.01			-1119.81			-1416.46			-1119.79

Notes: Dependent variable is the log of sales price. Category omitted for township is Beaufort (County Seat). Omitted year is 2000.

Table 4. Comparison between the Present Value of Flood Insurance Premiums and House Price Differentials

Properties within a 100-year Floodplain

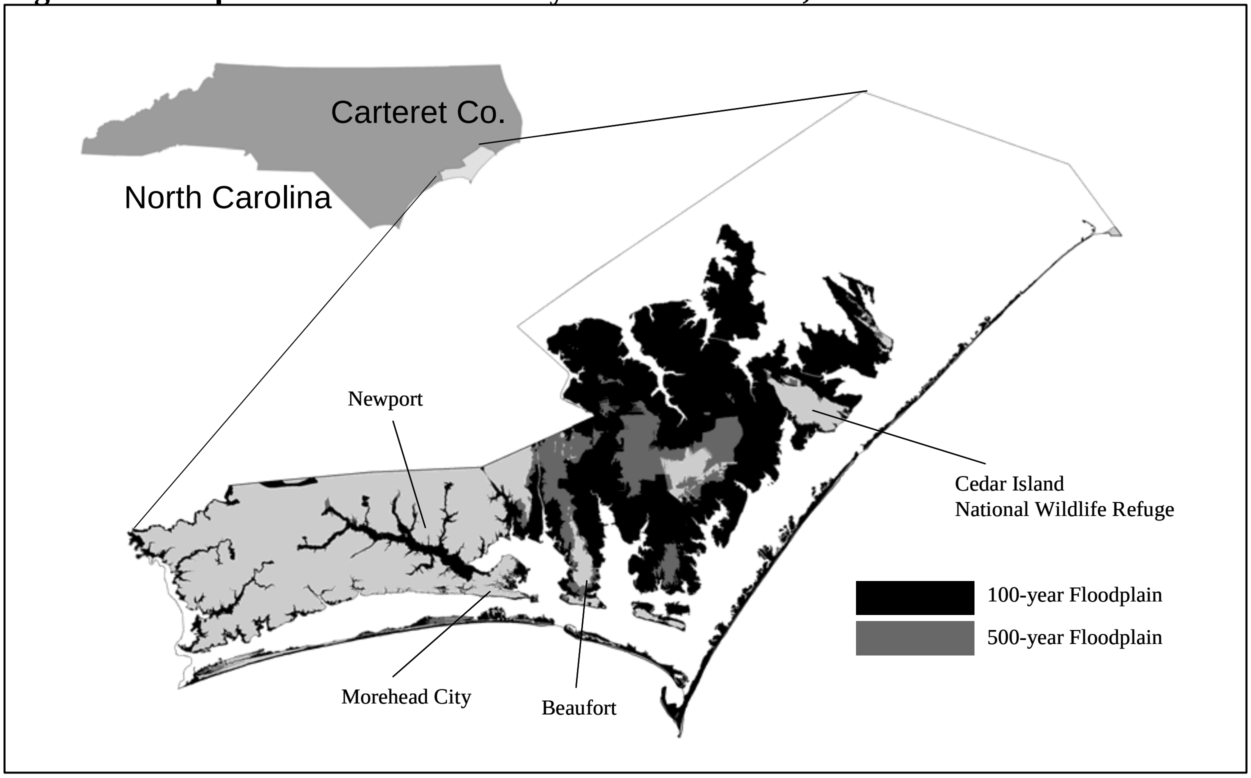
Property Value	Annual Insurance Premium	Present Value of Insurance Premium			Sales Price Differential
		4%	8%	12%	
Low ($75K)	$670	$16,750	$8,375	$5,583	$5,863
Avg. ($150K)	$840	$21,000	$10,500	$7,000	$11,726
High ($225K)	$961	$24,025	$12,013	$8,008	$17,589

Properties within a 500-year Floodplain

Zone Type	Annual Insurance Premium	Present Value of Insurance Premium			Sales Price Differential
		4%	8%	12%	
Low ($75K)	$408	$10,200	$5,100	$3,400	$4,648
Avg. ($150K)	$607	$15,175	$7,588	$5,058	$9,295
High ($225K)	$772	$19,288	$9,644	$6,429	$13,943

Notes: Flood insurance premium estimates are based on the post Flood Insurance Rate Maps (FIRM) for single-family houses without basement and enclosure. The content values of $5,000, $15,000, and $25,000 are assumed for the low, average, and high valued houses, respectively. A standard deductibles $500 for building and contents applies. Premiums include the federal policy fee and the increased cost of compliance (ICC).

Figure 1. Floodplains of Carteret County - North Carolina, USA



Notes: The mainland and the barrier islands of Carteret County are separated by Atlantic Ocean and intracoastal water. Dark-shaded areas denote 100-year floodplains and light-shaded areas represent 500-year floodplains.