Building Codes, Wind Contours, and House Prices

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Abstract A hedonic pricing model estimates the effect on house prices of the stricter 2002 Florida Building Code for three geographical areas with varying degrees of risk exposure in the Jacksonville, Florida area. Results show that houses built under the new, stricter code sold for an average premium of 12.33% relative to houses built under the less-strict code. Results also show that new-code properties in the riskiest Windborne Debris Region sold for about 4.7% more than houses built under the older, less strict code. The interior zones show that houses built under the stricter code sold for greater premiums. The post-catastrophe variables show that the two consecutive seasons of devastating hurricanes in 2004 and 2005 had an effect on buyer behavior and generally increased the building code premium.

The principal purpose of a building code is to establish minimum acceptable standards related to building materials and construction practices. Building codes related to residential real estate provide building standards that ultimately should result in greater safety for home occupants. While effective building codes in all geographic areas provide minimum safety standards, they are of critical importance in areas that are exposed to extreme events such as hurricanes, tornadoes, earthquakes, or flooding. It is not surprising that modifications in building codes often occur following catastrophes, when losses highlight weaknesses in existing codes. For example, the building code changed in California following the 1994 Northridge Earthquake. In Florida, the bellwether event was 1992's Hurricane Andrew, which led to major changes in 1994 and 2002 to harden homes against hurricane force winds.

Building code changes that require additional construction will add to the cost of construction. For example, requiring the use of hurricane straps, hurricane shutters, or stronger roof construction reduces a home's exposure to low-to-middle range hurricane force wind speeds (category 1 to 3 on the Saffir-Simpson Hurricane Wind Scale[1]) but these mitigation types of features come at a cost (higher grade materials and additional labor). In a market where building code changes result in increased safety for the newer housing stock, consumers would likely see a greater spread in value between newer and older homes (based on the cost approach). For a given expenditure in this type of market, the consumer's choice would be either to (1) pay a premium for a newer home with greater storm mitigation features/safety (but less amenities) or (2) acquire more square footage and/or additional amenities by buying an older home. As such, a significant change in the building code creates an interesting dynamic in housing consumption. Dehring (2006a), examining the impact of existing building codes, finds that they increase housing costs by approximately 5%. The author states that examining the impact of building code changes requires ‘‘consideration of any changes in information, safety benefits, such as reduced expected mortality and property damage.’’

The public policy issue of building codes can be viewed from three perspectives: (1) consumers' perceptions of the effectiveness of the building code, (2) consumers' perceptions regarding the tradeoff of increased safety and cost, and (3) the extent to which consumers' value safety. Concerns regarding the effectiveness of the building code can impact consumers' expenditures on housing. For example, if consumers perceive a building code change as ineffective, they would be unwilling to pay the additional costs and would opt for the alternative of purchasing the less expensive older-code home. As noted by Dehring (2006a), building code requirements do not guarantee the most cost-efficient process for obtaining safety objectives. Additionally, building codes and standards may be more reflective of political demands than engineering needs (Colwell and Kau, 1982).

A second important public policy issue of building codes is the tradeoff between improved performance (safety) and cost. Implementing building code changes that are designed to provide greater safety is much easier if consumers perceive that the increased safety outweighs the incremental cost. As such, the premium paid for safety would be offset by the perceived economic and non-economic benefits.[2] For example, in hurricane-prone areas, an argument may be that upgrading the housing stock through a new roof program would generate significant benefits to consumers in the form of lower insurance premiums and reduced likelihood of loss. The regulating authority (typically the state) would see a benefit from reducing the adverse economic impact of hurricanes and the ex post costs associated with recovery. The regulator would then be in a stronger position to argue for lower insurance premiums.

A third issue in building construction is the extent to which consumers value safety (i.e., consumers being willing to pay more for a stricter building code). In this setting, the notion of preference for safety (protection from loss of life or serious injury) could be expanded to include protection against loss of personal property and loss of the use of property for a substantial length of time.[3] Regarding natural disasters such as hurricanes and tornadoes, research by Meyer (2005) and others shows that perceived risk (and the willingness to pay to reduce risk) is not constant and is impacted both by events and the length of time between events. Thus, some participants in the home building industry have argued that consumers are not willing to pay extra for safety.[4]

In 2002, the state of Florida instituted the Florida Building Code. Effective in March 2002, it set stricter requirements for home construction and was designed to address hurricane mitigation by eliminating the state's existing patchwork of building regulations. Some of the major changes were designed to ensure that buildings in high-intensity hurricane areas could better withstand the impact of wind-borne debris.[5] In general, evidence shows that homes built under the 2002 Florida Building Code are better at withstanding major disasters. Gurley (2005), examining the damage caused by 2004 hurricanes Charley, Frances, Jeanne, and Ivan, concluded that homes built under the Florida Building Code sustained less damage than homes built between 1994 and 2001.

Dumm, Sirmans, and Smersh (2009, 2011) provide the first direct measure of the capitalization of a building code change into house prices. Previously, Noam (1982) examined the effect of building code restrictiveness on property values across cities and Dehring (2006a) examined the effect of building code changes on vacant land values. Although Dumm, Sirmans, and Smersh (2009, 2011) provide the milestone of examining the effect of building code changes on house prices, the data were contained completely in the ''Windborne Debris Region.'' When hurricanes make landfall, the highest wind speeds from a particular storm occur on or near the coast in the area known as the Windborne Debris Region (WBDR). This region in Florida is defined as areas where the basic wind speed is 120 miles per hour or areas within one mile of the coast that experience winds of 110 or greater miles per hour. To more broadly understand the effect of building code changes, this current study uses an expanded data set to include housing transactions that have substantial storm risk exposure but are outside the WBDR.

Dumm, Sirmans, and Smersh (2011), along with measuring the capitalization of the stricter 1994 South Florida Building Code into Miami house prices, also examine whether consumers' opinion of value changed with the ''reality check'' of the seven hurricanes occurring in 2004–2005. In addition to the model showing that the stricter building code had a positive effect on selling price, the post-catastrophe (reality check) variables show that, following the minimal impact of the 2004 hurricanes on the Miami area, the premium for structural integrity disappears. However, after the 2005 hurricanes, which were more devastating to the Miami area, the building code premium returns.

This study expands on Dumm, Sirmans, and Smersh (2011) and contributes to the real estate literature in several ways. First, examining the capitalization of the 2002 Florida Building Code into house prices has the advantage of examining consumer behavior in a market where there was a more recent strengthening in building code (2002 vs. the 1994 South Florida Building Code) that was followed by a series of catastrophic events with impacts at either the local or state level (heightened hurricane activity in 2004 and 2005). Second, the study uses Jacksonville, Florida housing data and although this area has experienced some hurricanes and other severe storms, it has historically enjoyed a lower storm risk exposure. In fact, Hurricane Dora in 1964 is the only hurricane to make landfall in Jacksonville since 1851. Thus the study incorporates differing attitudes toward risk exposure for Jacksonville residents versus Miami residents. Third, Dumm, Sirmans, and Smersh (2011) use Miami-Dade County data where the entire county is in the WBDR. On the other hand, the WBDR of the Jacksonville data comprises only about 12% of the sample. The Jacksonville data allows valuation of the stricter building code to consumers whose risk exposure expectations may be different/lower than consumers in South Florida. Fourth, the spatial aspect of the properties in the sample is observed by including each property's distance from the coast. Fifth, recognizing that property values are affected by positive/negative externalities, the effects of externalities on house price are considered within each of the WBDRs.

Storm Mitigation and Building Requirements

A building code is a set of rules designed to provide general public safety relative to buildings and other structures and is usually accomplished by specifying minimum construction standards. More broadly, residential construction building codes are justified for two reasons: they help to correct information asymmetries caused by homebuyer lack of expertise in valuing the structural integrity of a house and they help to prevent externalities that may endanger adjacent properties (Dehring, 2006b). Codes may apply both to the general construction of the building and to specific components such as size of rooms or door openings. Traditionally, code requirements have been both prescriptive (setting the rules on how construction is to be done) and performance-based (setting the required level of performance but not how it is achieved). In addition, code requirements tend to be reactive in that changes are typically made following catastrophic losses (e.g., hurricane, earthquake), as these events serve to identify unacceptable weaknesses in the construction of the existing housing stock.

Regulations on building and construction can be traced back to early recorded history. Hammurabi, the sixth Babylonian king, enacted the ancient law code, The Code of Hammurabi, around 1790 BC (see Handcock, 1920). The Code provided various laws, including one related to construction such that if a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills the owner (or the owner's son or slave), then that builder (or builder's son or slave) shall be put to death. An early form of building code is also provided in the King James version of the Bible in Deuteronomy 22:8 as stated in the Law of Moses: "When thou buildest a new house, then thou shalt make a battlement (railing) for thy roof, that thou bring not blood upon thine house, if any man fall from thence."

In colonial times, George Washington and Thomas Jefferson, for public health and safety reasons, advocated for building regulations to establish minimum standards. As the country grew, building code regulations in the early 1900s were established by local enforcement authorities in conjunction with participants of the building industry. The first formal building code organization, the Building Officials and Code Administrators (BOCA) International, Inc., formed in 1915.

The second organization, the International Conference of Building Officials (ICBO), was formed in 1922 and represented building code officials from the western United States. A third organization, the Standard Building Code Congress International (SBCCI), was formed in 1941 to represent building code officials in the southern U.S. Finally, the nonprofit organization, the International Code Council (ICC), was established in 1944 for the purpose of developing a single set of comprehensive national construction codes.[6]

Florida began mandating statewide building codes during the construction boom of the 1970s. These codes provided "state minimum building code" guidelines for municipalities and counties. In the 1990s, prompted by natural disasters and an increasingly complex system of regulations, a comprehensive review of the state building code system was undertaken. This led to the 1998 Florida Legislature creating a statewide building code, the Florida Building Code, which became effective in 2002.[7] Local governments may amend the requirements but only to make them more stringent.[8]

Storm Mitigation, Public Policy, and Consumer Behavior

The public policy implications surrounding building codes are significant. In Florida, for example, the 2006 Task Force on Long-term Solutions to the Florida Property Insurance Market noted in its report that the building code changes designed to harden homes (i.e., greater resistance to extreme wind speeds) in the aftermath of Hurricane Andrew were clearly evident in the performance of the housing stock during the 2004 hurricane season (Task Force on Long-Term Solutions for Florida's Hurricane Insurance Market Report, p. 4). Stronger homes not only reduce expected loss costs from hurricanes, but as noted above, they also reduce potential loss of life, loss of items of significant personal value (e.g., family photographs or other heirlooms), and minimize major disruptions in the event the home is uninhabitable.

Given the substantial increase in Florida homeowner premiums since the 2004 hurricane season, insurance credits for mitigation have becoming increasingly attractive in achieving lower homeowner insurance premiums.[9] Public policymakers recognize that improving the strength of the building stock is critical in any attempt to improve the property insurance marketplace in Florida. As such, it becomes imperative to understand consumer preferences for stronger and safer homes and their willingness to pay for higher levels of safety. A strong preference for safe structures among consumers provides impetus for increased government action or legislation.[10] Mitigation provides the hope for a future of lower losses and less price volatility. As such, the importance of effective mitigation cannot be understated. The Florida Building Code can be considered a package of mitigation features that has changed over time in tandem with structural engineering advancements such as building technique improvements and add-on types of mitigation features (e.g., storm shutters). Economic value can be created directly with mitigation credits (reducing the homeowner's premium) and indirectly if the structure remains intact (e.g., avoids or reduces loss of valuable personal items, costs of living elsewhere while the home is being repaired or rebuilt).

Within the context of the economic benefit of storm mitigation, the primary questions of interest in this study are:

- Are consumers willing to pay a premium for safety (as measured by stricter building codes) when purchasing homes in areas exposed to catastrophic storm loss?
- Do consumers factor in locational risk (e.g., coastal vs. inland) in their pricing decisions?
- Are consumer preferences for safety impacted by broader hurricane activity when a local region has not experienced significant hurricane losses?

While the engineering benefits of a home built under the newer building code are clear and easily understood, the questions above relate to whether and to what degree consumers are willing to pay for improved structural performance.

Although the focus of this paper is on a market exposed to catastrophic storm risk, it is important to recognize that the potential impact of mitigation applies to markets with other catastrophic exposures (e.g., flood, earthquake). While studies such as Simmons and Sutter (2007) and Dumm, Sirmans, and Smersh (2011) have found evidence indicating that consumers are willing to pay a premium for safety, the results from the existing literature are mixed.[11] By addressing the questions above this study provides additional insights into consumer behavior regarding exposure to catastrophic risk. As Meyer (2008) suggested, "the consumer's sense of risk oscillates between these two extremes driven by the most recent activity."

Data and Methodology

The methodology is designed to examine two issues: the effect of a change in building codes on house prices and whether consumers' perceptions of storm mitigation (building codes) are changed after major catastrophic events.

The Empirical Model

Real estate research has typically used hedonic regression analysis to measure the marginal effects of housing characteristics on house prices. A review by Sirmans, Macpherson, and Zietz (2005) of 125+ real estate studies using hedonic pricing models shows inclusion of a large number of variables. However, only the recent hedonic model by Dumm, Sirmans, and Smersh (2009, 2011) has included a variable to measure the capitalization of building codes.

The basic form of the hedonic pricing model has been:

$$\ln(sp) = \alpha_0 + \beta_i X_{ij} + \varepsilon_i,$$

where selling price (*sp*) is expressed in logged form (price is deflated to reflect 2003 values), α_0 is a constant term, β_i is the regression coefficient for the i^{th} housing characteristic, X_{ij} is a vector of housing characteristics (structural/locational) and demographic variables such as average household size and income) for property *j*, and ε_i is the residual error term. The hedonic model is expanded to include a binary variable to represent whether a house was built under the new or old code. If a stricter building code reflects greater safety and assuming this is valued by consumers, houses built under the new, stricter building code should sell for higher prices relative to houses built under the less strict code, other things constant.

The model also includes variables to measure whether the 2004 and 2005 hurricanes were a reality check and whether they raised safety concerns and building code awareness for home buyers. These variables measure, for houses that sold immediately after these catastrophic events, whether there were differences in selling prices based on different building codes. To the extent that these recent disasters created greater public awareness of severe storm danger and an increased the desire for safety, houses with stricter building codes would be expected to sell for a price premium relative to houses with the less-strict code.

With the additional variables, the hedonic model becomes:

$$\begin{aligned}\ln(sp) = {} & \alpha_0 + \beta_i X_{ij} + \beta Bldgcode_j + BldgcodePostH1_j \\ & + BldgcodePostH2_j + BldgcodePostH3_j + \varepsilon_i,\end{aligned}$$

where $Bldgcode_j$ is the building code for property *j*. *Bldgcode* is a binary variable that takes the value of one if the house was built after the 2002 stricter building code change in Florida and zero if the house was built before the code change. This variable will test whether there is a price differential for properties sold under the different building codes. If consumers value disaster mitigation and if a stricter building code reflects this, the coefficient on $Bldgcode_j$ will be positive.

$BldgcodePostH1_j$, $BldgcodePostH2_j$, and $BldgcodePostH3_j$ are interactive reality check variables between building code and the periods after the major hurricanes of 2004 and 2005 for property *j*. The four hurricanes of 2004 occurred in August and September 2004 and the three hurricanes that impacted Florida in 2005 occurred in July through October. $BldgcodePostH1_j$ represents properties built under the new code that sold from December 2004 through May 2005. This is the time between the 2004 and 2005 hurricane seasons.[12] $BldgcodePostH2_j$ represents houses built under the new code that sold from December 2005 through May 2006. This is the time between the last hurricane of 2005 and the start of the 2006 hurricane season. $BldgcodePostH3_j$ represents houses built under the new code that sold after the end of the 2006 hurricane season (December 2006 through 2008).[13]

The Data

The empirical models are estimated using transactions-level data for owner-occupied, single-family home sales in the Jacksonville, Florida housing market for the period 2003 through 2008. Jacksonville is the county seat of Duval County, Florida. As a result of a 1968 consolidation of city and county governments and an expansion of the city limits to include almost the entire county, Jacksonville has since been the largest city in land area in the contiguous U.S. Jacksonville is located in the First Coast region of northeast Florida and is centered on the St. Johns River. The city was originally founded in 1791 and was known as Cowford, so named for a narrow point in the river where cattle crossed. The city was renamed in 1822 in honor of Andrew Jackson, the first military governor of the Florida Territory.

The primary hurricane risk to homeowners is wind. The Jacksonville real estate market includes three windzones.[14] The coastal wind zone with the greatest risk exposure, the WBDR, contains about 12% of the housing stock and is identified as the designated area where the basic wind speed is 120 mph or greater. For much of Duval County this is approximately 6.8 miles from the coastline. The wind zones are identified as:

Windborne Debris Region:	Binary variable with a value of one if the house is located within the WBDR (east of the 120 mph contour), and zero otherwise;
110 mph Zone:	Binary variable with a value of one if the house is within the 110 mph wind zone, zero otherwise; and
100 mph Zone:	Binary variable with a value of one if the house is located within the 100 mph wind zone, zero otherwise.

Data are available from the 2000 census of Population and Housing regarding household size and median household income. This was taken at the census block group level. There are 422 block groups within Duval County. Variables are created to represent the spatial distribution of household income for each house based on the block group in which it is located. The final data set contains 68,952 home sales and includes those houses that were sold between 2003 and 2008. To account for inflation, the house prices are deflated to reflect 2003 values.

While the primary interest in this study with regard to location is the effect of hurricane risk exposure on price (measured as distance from the nearest coastal point[15]), the model also includes measurements of proximity to positive and negative externalities, since there can be other location effects on price. Neoclassical location theory (e.g., Alonso, 1964; Muth, 1968; and Mills, 1972) posits the existence of a single land value gradient that declines with distance from the central point in an urban area. More recently, the concept of accessibility has been expanded to include distances to multiple nodes and axes such as influential urban (employment) centers and transportation arteries (e.g., Li and Brown, 1980; Heikkila, Gordon, Kim, Peiser, and Richardson, 1989; and Waddell, Berry, and Hoch, 1993). Externalities such as amenities or nuisances will also be capitalized into property values (e.g., Henderson, 1977; and Diamond, 1980) and are often regarded as having distance-decay effects.

A number of studies have examined the effects of externalities on house prices. Externalities have ranged from being positive such as proximity to a golf course (Schultz and Schmitz, 2009), resort community (Spahr and Sunderman, 1999), or waterfront view (Benson, Hansen, Schwartz, and Smersh, 1998) to negative such as environmental contamination (underground storage tanks, etc.) (Simons, Bowen, and Sementelli, 1997; Boyle and Kiel, 2001; and Simons and Saginor, 2006), landfills (Ready, 2010), flood zones (Harrison, Smersh, and Schwartz, 2001), or power lines (Des Rosiers, 2002).

Exhibit 1 shows a sample of externality locations for Duval County. The externality locations used in this study are:

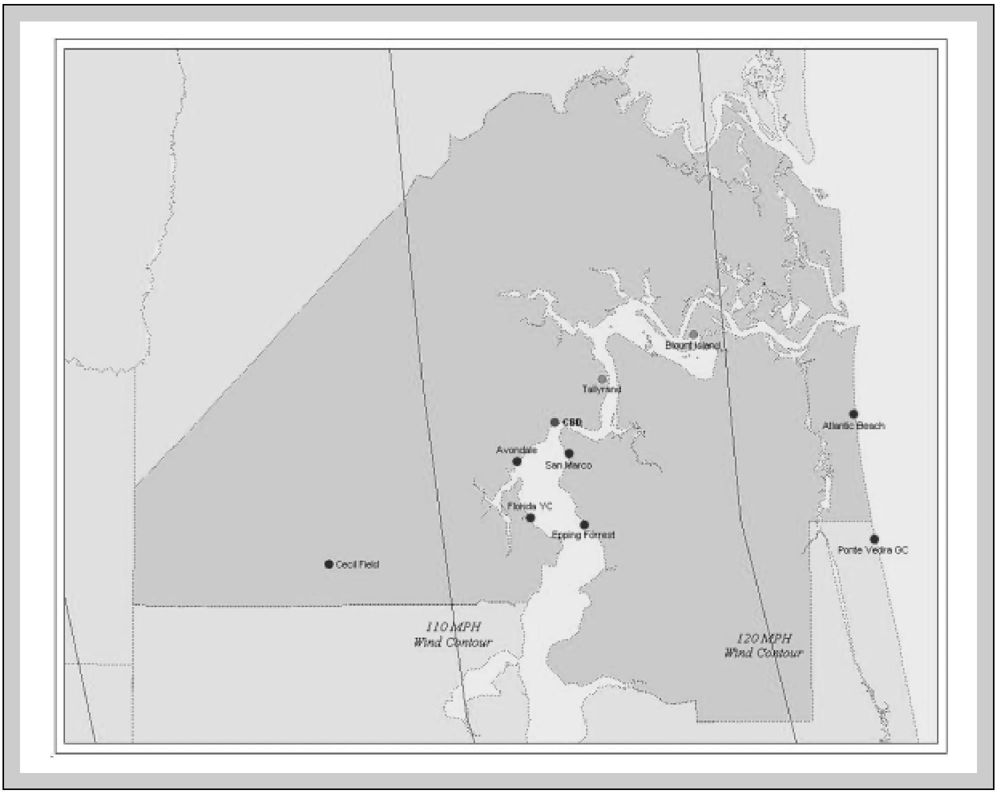
Region	Name (Type)	Description
WBDR	Ponte Vedra (+)	Ponte Vedra Golf Club in St. John's County on Ponte Vedra Blvd
110 mph zone	San Marco (+)	Heart of San Marco (the Swisher Estate) on River Road
	Epping Forrest (+)	The former DuPont Estate on Epping Forrest Way
	Florida YC (+)	The Florida Yacht Club on the dead end of Yacht Club Road
	Avondale (+)	Heart of Avondale on the corner of Richmond and Ingleside
	Talleyrand (−)	Talleyrand Docks on Talleyrand Avenue and 18th Street
	Blount Island (−)	Blount Island shipping terminal on Propeller and Maritime
100 mph zone	Cecil Field (+)	Cecil Field Air Station

For the 110 mph zone, two variables were created: one to indicate the closest positive externality location between San Marco, Epping Forrest, Florida YC, or Avondale (*CloseposExt*), and one to indicate the closest negative externality location between the property and Talleyrand or Blount (*ClosenegExt*).[16]

Data Summary Statistics

Exhibit 2 contains the definitions of the variables included in the model and Exhibit 3 provides summary statistics for the variables. For the aggregate sample

Exhibit 1 | Sample Externality Locations for Duval County



of 68,952 home sales between 2003 and 2008, the average deflated selling price was $171,673. The average square footage was 1,737 and the average lot size was 0.30 acres. The average age was 25 years. About 27% of the houses sold were built under the new building code. The average number of bedrooms and bathrooms was 3.20 and 2.03, respectively. An examination of the average housing characteristics indicates that about 50% of homes had a fireplace, 9% had a swimming pool, 5.5% had a deck, and 70% had a garage. The average household size was 2.6 persons and the average household income was $52,400. The average distance from the coast was 15.4 miles. The proportion of homes sold each year increases constantly through 2005, after which it steadily declines through 2008. The number of homes sold each quarter increases through the year. About 12% of the homes in the data sample are located in the WBDR. In contrast, 72% of homes are located in the 110 mph zone and 16% of homes are located in the area with the lowest risk exposure, the 100 mph zone.

Exhibit 2 | Variable Definitions

Variable	Definition
Ln(sp)	Log of sale price ln(*sp*) = dependent variable (Deflated to reflect 2003 values).
Age	Age of house at the time of sale.
SqFt	The square footage of the house.
Bldgcode	Binary variable with a value of one if the house was built under the stricter 2002 Florida Building Code, zero otherwise.
Bed	Number of bedrooms.
Bath	Number of bathrooms.
LotSize	Size of the lot in acres.
Fireplace	Binary variable with a value of one if the house has a fireplace, zero otherwise.
Pool	Binary variable with a value of one if the house has a pool, zero otherwise.
Deck	Binary variable with a value of one if the house has a deck, zero otherwise.
Garage	Binary variable with a value of one if the house has a garage, zero otherwise.
HhSize	Average household size by census block.
HhIncome	Average household income by census block.
WBDR	Binary variable for location within the Windborne Debris Region, zero otherwise.
100 mph	Binary variable for location within the 100 mph wind zone, zero otherwise.
110 mph	Binary variable for location within the 110 mph wind zone, zero otherwise.
Distance	Spatial variable measuring distance in miles of the parcel from nearest coastal point.
Ponte Vedra	Spatial variable measuring distance to Ponte Vedra Golf Course (positive externality in the WBDR).
CloseposExt	Spatial variable measuring the minimum distance the nearest positive externality in the 110 mph zone (Locations = Avondale, Florida Yacht Club, San Marco, Epping Forrest).
ClosenegExt	Spatial variable measuring the minimum distance to the nearest negative externality in the 110 mph zone (Locations: Blount Island, Tallyrand).
Cecil Field	Spatial variable measuring distance to Cecil Field (externality in the 100 mph zone).
Qtr1	Binary variable if the house was sold during the first quarter of the year (January, February, March), zero otherwise (*Qtr 1* is the omitted variable).
Qtr2	Binary variable if the house was sold during the second quarter of the year (April, May, June), zero otherwise.
Qtr3	Binary variable if the house was sold during the third quarter of the year (July, August, September), zero otherwise.
Qtr4	Binary variable if the house was sold during the fourth quarter of the year (October, November, December), zero otherwise.
Y2003–Y2008	Time trend variables for the years 2003 through 2008 (*Y2003* is the omitted year).

Exhibit 2 | (continued)

Variable Definitions

Variable	Definition
BldgcodePostH1	Binary variable representing properties built under the new code that sold December 2004 through May 2005.
BldgcodePostH2	Binary variable representing houses built under the new code that sold December 2005 through May 2006.
BldgcodePostH3	Binary variable representing houses built under the new code that sold after the end of the 2006 hurricane season (December 2006 through 2008).

Wind Zone Data Characteristics

The WBDR contains homes sold during the 2003–2008 period that are located within 120 mph wind contour or within the 110 mph zone and 1 mile of the coast. This region has the greatest exposure to extreme hurricane risk. Of the total sample, 8,173 sales came from the WBDR. These houses had an average selling price of $219,607 (deflated), an average size of 1,933 square feet, and a lot size of 0.27 acres. These houses were, on average, 10.68 years old and about 27% of these houses were built under the new building code.

The largest proportion of the sample was located in the 110 mph zone (49,717 out of 68,952 home sales). Although these homes would have less risk exposure than homes in the WBDR, they could still be subjected to extreme conditions. The average selling price for homes in this area ($167,944) was less than the average price in the WBDR. These houses had an average of 1,699 square feet and had average lot sizes of 0.29 acres. The average age for houses sold in this area was 30.03 years. A smaller percentage of the houses sold in the 110 mph zone (22%) relative to the WBDR were built under the new building code. As noted above, distance to the nearest positive and negative externality location were calculated for each property in the 110 mph zone and the average distance to the nearest positive (negative) externality was 5.7 miles (7.6 miles).

The 100 mph zone contains the 11,060 properties that are located on the leeward side of the wind contour. The risk exposure for these houses would be expected to be somewhat less than for properties located in the other two zones. The average house price is lowest for this zone ($153,016). The average house size was 1,763 square feet and the average lot size was 0.38 acres. These houses were, on average, 10.30 years old, comparable to the average age in the coastal but much shorter than the average age for the middle zone. Fifty percent of these homes were built under the new building code. Cecil Field was used as a positive externality location and the average distance to Cecil Field for properties in the 100 mph zone was 5.6 miles.

Exhibit 3 | Descriptive Statistics

	Panel A: Aggregate (*N* = 68,952)				Panel B: Wind Born Debris Region (*N* = 8,173)			
Variable	Mean	Min.	Max.	Std .Dev.	Mean	Min.	Max.	Std. Dev.
Price (defl)	171,672.90	43,165.07	4,036,812	120,834.10	219,607.30	50,213.14	3,281,905.0	131,261.30
Age	24.570	0	121	23.873	10.676	0	87	10.250
SqFt	1,736.986	700.00	14,828	657.326	1,932.841	720.00	11,628.00	614.553
Bldgcode	0.272	0	1	0.445	0.272	0	1	0.445
Bed	3.199	1	8	0.733	3.338	1	8	0.632
Bath	2.028	1	8	0.643	2.224	1	8	0.504
LotSize	0.299	0.01	18.28	0.462	0.270	0.015	9.992	0.295
Fireplace	0.496	0	1	0.500	0.662	0	1	0.473
Pool	0.087	0	1	0.282	0.109	0	1	0.312
Deck	0.055	0	1	0.227	0.048	0	1	0.214
Garage	0.695	0	1	0.461	0.897	0	1	0.304
HhSize	2.639	1.22	3.85	0.314	2.869	1.50	3.85	0.310
HhIncome	52,399.080	15,313.00	200,001	17,108.430	62,751.060	29,583	92,881	8,856.976
Distance	15.415	0.040	39.640	6.490	4.915	0.04	9.60	1.520
Ponte Vedra					8.798	1.47	21.23	2.298
WBDR	0.119	0	1	0.323				

Exhibit 3 | (continued)

Descriptive Statistics

	Panel A: Aggregate (*N* = 68,952)				Panel B: Wind Born Debris Region (*N* = 8,173)			
Variable	Mean	Min.	Max.	Std .Dev.	Mean	Min.	Max.	Std. Dev.
110 mph	0.160	0	1	0.367				
100 mph	0.721	0	1	0.448				
Qtr 1	0.192	0		0.394	0.155	0	1	0.362
Qtr 2	0.259	0	1	0.438	0.215	0	1	0.411
Qtr 3	0.269	0	1	0.443	0.223	0	1	0.416
Qtr 4	0.279	0	1	0.449	0.406	0	1	0.491
BldgcodePostH1	0.030	0	1	0.172	0.038	0	1	0.191
BldgcodePostH2	0.025	0	1	0.155	0.021	0	1	0.142
BldgcodePostH3	0.057	0	1	0.231	0.043	0	1	0.202
Y2003	0.180	0	1	0.384	0.214	0	1	0.410
Y2004	0.203	0	1	0.402	0.234	0	1	0.424
Y2005	0.248	0	1	0.432	0.241	0	1	0.428
Y2006	0.192	0	1	0.394	0.160	0	1	0.367
Y2007	0.114	0	1	0.318	0.096	0	1	0.295
Y2008	0.062	0	1	0.242	0.055	0	1	0.227

Exhibit 3 | (continued)

Descriptive Statistics

	Panel C: 110 mph Zone (*N* = 49,717)				Panel D: 100 mph Zone (*N* = 11,060)			
Variable	Mean	Min.	Max.	Std. Dev.	Mean	Min.	Max.	Std. Dev.
Price (defl)	167,943.60	43,165.07	4,036,812.00	127,938.80	153,015.60	44,537.16	595,455.40	51,052.190
Age	30.029	0	121	25.028	10.297	0	102	13.391
SqFt	1,699.070	700.000	14,828.000	686.691	1,762.704	700.000	4,259.000	509.364
Bldgcode	0.220	0	1	0.414	0.504	0	1	0.500
Bed	3.152	1	8	0.759	3.310	1	8	0.653
Bath	1.974	1	8	0.681	2.128	1	8	0.502
LotSize	0.287	0.010	18.280	0.434	0.376	0.030	12.078	0.640
Fireplace	0.477	0	1	0.499	0.459	0	1	0.498
Pool	0.089	0	1	0.284	0.062	0	1	0.241
Deck	0.061	0	1	0.239	0.032	0	1	0.175
Garage	0.627	0	1	0.484	0.851	0	1	0.356
HhSize	2.555	1.220	3.590	0.302	2.846	2.400	3.110	0.143
HhIncome	51,716.900	15,313	200,001	19,005.000	47,815.980	20,481	61,250	6,391.850
Distance	14.949	6.750	23.260	4.165	25.266	23.010	39.640	1.848
CloseposExt	5.744	0.030	18.260	3.366				
ClosenegExt	7.588	0.310	18.790	3.814				

Exhibit 3 | (continued)

Descriptive Statistics

	Panel C: 110 mph Zone (*N* = 49,717)				Panel D: 100 mph Zone (*N* = 11,060)			
Variable	Mean	Min.	Max.	Std. Dev.	Mean	Min.	Max.	Std. Dev.
Cecil Field					5.559	1.240	15.260	1.746
Qtr 1	0.195	0	1	0.396	0.208	0	1	0.406
Qtr 2	0.266	0	1	0.442	0.263	0	1	0.440
Qtr 3	0.274	0	1	0.446	0.281	0	1	0.449
Qtr 4	0.266	0	1	0.442	0.248	0	1	0.432
BldgcodePostH1	0.023	0	1	0.150	0.058	0	1	0.234
BldgcodePostH2	0.021	0	1	0.142	0.046	0	1	0.209
BldgcodePostH3	0.050	0	1	0.217	0.099	0	1	0.298
Y2003	0.177	0	1	0.382	0.170	0	1	0.375
Y2004	0.199	0	1	0.399	0.199	0	1	0.399
Y2005	0.247	0	1	0.431	0.255	0	1	0.436
Y2006	0.196	0	1	0.397	0.200	0	1	0.400
Y2007	0.117	0	1	0.321	0.116	0	1	0.320
Y2008	0.064	0	1	0.245	0.060	0	1	0.238

Empirical Results

Results for the Aggregate Data

The regression results for the aggregate model are presented in column on of Exhibit 4. The adjusted R-squared for the aggregate regression model is 0.78 and the VIF factors indicate no problems with multicollinearity.[17] The housing characteristics variables behave as expected with the exception of bedrooms, which was positive but not significant. Square footage, lot size, number of bathrooms, fireplace, pool, deck, and garage all have a positive effect on selling price. The age variable is negative. The zone variables show that house prices decline as distance from the coast increases.[18] Household size has a negative effect on selling price whereas household income has a positive effect. The year variables show that house prices peaked in 2006, then declined through 2008. The quarterly variables show that comparable houses tend to sell for higher prices in the last half of the year versus the first half.

The variables of primary interest are $Bldgcode_j$, $BldgcodePostH1_j$, $BldgcodePostH2_j$, and $BldgcodePostH3_j$. The $Bldgcode_j$ coefficient is positive, indicating that houses built under the new, stricter building code sold for about 12.33% more on average relative to houses built under the old, less strict code. The post-catastrophe variables provide some interesting insight into buyer behavior. $BldgcodePostH1_j$ shows that, following the 2004 hurricanes, the pricing gap between houses built under the two codes became narrower, with the new-code premium decreasing slightly to about 10.6%. However, buyer behavior reverses after the 2005 hurricane season and the new-code premium increases to about 16%, as shown by $BldgcodePostH2_j$. This result is not surprising given the cumulative effect of the losses from the two consecutive devastating hurricane seasons. Moving into 2007 and 2008, the building code premium decreases (to about 10%) as periods of much milder hurricane seasons occur, as shown by $BldgcodePostH3_j$.[19]

Results for the Wind Zones

Results for the WBDR are shown in column two of Exhibit 4. The adjusted R-squared for the model is 0.79 and the housing characteristics and other variables behave as expected, with the exceptions of bathrooms, fireplace, and deck, which are not significant. The distance variable shows that property prices decline as distance from the coast increases. The positive externality variable (Ponte Vedra) indicates that property values decline as distance from this location increases. The building code variable shows that consumers in this highest-risk zone were differentiating between homes built under the two codes and that homes built under the stricter code were reflecting a premium of 4.68%. The reality check variables for the WBDR show that, immediately after the hurricanes of 2004

Exhibit 4 | Regression Model Output: Aggregate and By Zone

	Aggregate			WBDR			110 mph Zone			100 mph Zone		
	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF
Constant	11.1559*	0.0151		11.6018*	0.0377		11.0617*	0.0159		10.8124*	0.0640	
Age	−0.0002*	0.0001	2.70	−0.0018*	0.0005	2.14	−0.0004*	0.0001	3.33	−0.0015*	0.0003	3.08
SqFt	0.0004*	0.0000	2.54	0.0004*	0.0000	2.81	0.0003*	0.0000	2.52	0.0004*	0.0000	2.79
Bldgcode	0.1233*	0.0037	2.48	0.0468*	0.0085	2.29	0.1773*	0.0046	2.68	0.0763*	0.0057	3.16
Bed	0.0050	0.0032	1.78	0.0230*	0.0063	1.82	0.0070	0.0037	1.75	0.0122*	0.0035	2.03
Bath	0.0439*	0.0043	2.39	−0.0092	0.0095	2.26	0.0504*	0.0051	2.49	−0.0156*	0.0049	1.89
LotSize	0.0903*	0.0040	1.07	0.1576*	0.0175	1.18	0.1260*	0.0077	1.12	0.0621*	0.0052	1.28
Fireplace	0.0767*	0.0023	1.25	−0.0075	0.0049	1.14	0.0974*	0.0029	1.28	0.0594*	0.0032	1.19
Pool	0.1263*	0.0037	1.11	0.1180*	0.0078	1.09	0.1210*	0.0045	1.13	0.1169*	0.0073	1.06
Deck	0.0501*	0.0051	1.03	0.0137	0.0136	1.05	0.0649*	0.0057	1.03	−0.0782*	0.0119	1.06
Garage	0.1533*	0.0028	1.53	0.1289*	0.0115	1.24	0.1397*	0.0030	1.47	0.2296*	0.0087	1.60
HhSize	−0.2332**	0.0039	1.40	−0.2312*	0.0105	1.48	−0.1690*	0.0046	1.31	−0.1384*	0.0166	2.00
HhIncome	0.0000*	0.0000	1.45	0.0000*	0.0000	1.13	0.0000*	0.0000	1.79	0.0000*	0.0000	2.12
100 MPH	−0.1607*	0.0031	2.17									
110 MPH	−0.1497*	0.0031	2.41									
Distance				−0.0641*	0.0029	2.58	−0.0090*	0.0003	1.87	0.0073*	0.0017	1.53
Ponte Vedra				−0.0047**	0.0023	2.85						

Exhibit 4 | (continued)

Regression Model Output: Aggregate and By Zone

	Aggregate			WBDR			110 mph Zone			100 mph Zone		
	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF	Coeff.	S.E.	VIF
CloseposExt							−0.0162*	0.0005	2.15			
CloseneqExt							0.0017*	0.0004	2.06			
Cecil Field										−0.0037*	0.0012	1.27
Qtr 2	0.0212*	0.0025	1.75	0.0216*	0.0062	1.90	0.0230*	0.0031	1.74	0.0110**	0.0042	1.69
Qtr 3	0.0404*	0.0025	1.83	0.0347*	0.0063	1.99	0.0436*	0.0031	1.81	0.0241*	0.0045	1.88
Qtr 4	0.0680*	0.0026	1.83	0.0561*	0.0063	2.50	0.0572*	0.0031	1.77	0.0425*	0.0044	1.75
BldgcodePostH1	−0.0175*	0.0041	1.25	−0.0543*	0.0117	1.28	−0.0061	0.0057	1.22	−0.0179**	0.0065	1.39
BldgcodePostH2	0.0343*	0.0044	1.21	0.0211	0.0122	1.17	0.0379*	0.0060	1.20	0.0225*	0.0063	1.31
BldgcodePostH3	−0.0202*	0.0041	1.72	−0.0198	0.0120	1.54	−0.0302*	0.0053	1.69	−0.0169**	0.0074	2.19
Y2004	0.0712*	0.0026	1.70	0.0854*	0.0061	1.63	0.0732*	0.0032	1.71	0.0618*	0.0043	1.75
Y2005	0.1785*	0.0027	1.90	0.2133*	0.0064	1.74	0.1828*	0.0032	1.90	0.1731*	0.0047	2.12
Y2006	0.2719*	0.0028	1.77	0.3004*	0.0072	1.57	0.2796*	0.0034	1.79	0.2703*	0.0050	1.96
Y2007	0.2531*	0.0036	1.69	0.2441*	0.0090	1.53	0.2627*	0.0042	1.66	0.2568*	0.0075	2.11
Y2008	0.1147*	0.0044	1.46	0.1066*	0.0107	1.35	0.1259*	0.0053	1.45	0.0986*	0.0091	1.68
R^2	0.78			0.79			0.79			0.78		

Notes: The dependent variable is ln(*sp*). *N* = 68,952 for Aggregate; *N* = 8,173 for WBDR; *N* = 49,719 for 110 mph zone; and *N* = 11,068 for 100 mph zone. S.E. is HC3 Standard Error.

*Significant at the 1% level.

**Significant at the 5% level.

(having minimal impact), the new-code premium declined and became slightly negative (at about 1%). After the 2005 hurricane season, however, the premium increased to about 6.80%. After the relatively calm 2006 and 2007 hurricane seasons, the building code premium returned to its original amount of 4.68%.

Column three of Exhibit 4 gives the results for the 110 mph zone. The adjusted R-squared is 0.79. The housing characteristics and the other variables behave as expected. The distance variable again shows that price decreases with distance from the coast, although the effect of distance is much less for this zone than the coastal zone. The externality variables perform as expected with property values decreasing with distance from the nearest positive externality and increasing with distance from the nearest negative externality. The coefficient for building code is 17.73%, indicating that the stricter code was valued by consumers in this zone and new-code homes sold for more than old-code homes. The post-catastrophe reality check variables show an interesting pattern. The new-code premium remains unchanged after the 2004 hurricane season and increases to 21.52% after the 2005 hurricane season. After the relatively calm 2006 and 2007 hurricane seasons, the building code premium decreases to slightly less than 15%.

Column four of Exhibit 4 gives the results for the 100 mph zone, the most inland area. The adjusted R-squared is 0.78 and the housing characteristics and other variables again behave as expected, with the exception of bathrooms and deck, which have negative coefficients. The distance variable is now positive. This is likely a function of the fact that houses in this zone are located almost exclusively west of the city business/employment center (which stands between these homes and the coast). Thus the distance variable is likely as much reflecting distance from the city center as it is distance from the coast. The positive externality variable (Cecil Field) shows that properties decrease in value as distance from Cecil Field increases. The building code coefficient for this zone is 7.63%, indicating that new-code homes sold for almost 8% more, on average, than homes built under the older, less strict code. The coefficient for $BldgcodePostH1_j$ shows that, after the 2004 hurricanes the building code premium decreased slightly (to about 6%). However, after the 2005 hurricane season, $BldgcodePostH2_j$ shows an increase in the new-code premium to almost 10%. After the relatively calm 2006 and 2007 hurricane seasons, the building code premium dropped slightly to about 6%.

Understanding the Building Code Premiums

Overall, the results show that home buyers in all the wind zones recognize the value of the stricter building code and are willing to pay a premium for this storm mitigation. The premium is highest in the middle zone and lowest in the coastal zone. This lower premium in the coastal zone could be a function of how the value for these properties is derived. For properties on the coast, the value of the land likely outweighs the value of the home. Thus, even if the house is destroyed, the land value remains and it may be more efficient and cost-effective to insure against hurricane catastrophe than to mitigate against it.

The negative premium for the building code after the 2004 hurricane season in the coastal zone may seem counterintuitive, as the worst one might expect is consumer indifference across building codes. However, this negative result actually is consistent with the moral hazard problem of hurricanes and insurance discussed by Fronstin and Holtmann (1994). They argue that the ease with which disaster insurance can be substituted for disaster mitigation (more solid construction) affects consumers' preferences for product characteristics. Under these circumstances, a negative premium for a stricter building code is not surprising.

Of course, the ease with which insurance might replace disaster mitigation is affected by the availability and affordability of insurance. Homeowners saw their premiums increase after the 2004 hurricane losses. As in Dumm, Sirmans, and Smersh (2008), in 2004 differences in insurance premiums between old-code homes and new-code homes did not adequately reflect the mitigation benefits of the new-code home. Consumers were purchasing homes in a market where prices and other costs of home ownership (e.g., property taxes) were increasing. Without sufficient differences in insurance premiums between old-code and new-code homes, it would appear that, in some cases, consumers in the coastal zone may not have found it necessary or efficient to pay a premium for storm mitigation.

In contrast to the building code premium results for the coastal zone, the results for the two inland zones consistently show that consumers value the stricter code. It is interesting that, although the 2004 hurricanes produced substantial devastation across Florida (but not in Jacksonville), the code value decreased (or, at best, stayed constant as in the 110 mph zone). However, after two devastating back-to-back seasons (although still no direct Jacksonville hit), consumer attitudes toward building codes changed and is reflected in an increase in the code premium.

Then afterwards, despite predictions of highly active hurricane seasons in 2006 and 2007, no hurricanes made landfall in Florida. The third reality check variable captures a time period where forecasts of continued heightened hurricane activity proved to be inaccurate. It also reflects the passage of time from the significant losses of 2005. The building code premium goes down in the two most inland zones. A possible explanation could be the ''test of time'' syndrome. A homebuyer may not see the benefit of paying as great a premium for a new-code home (which may have fewer amenities for a given expenditure) relative to an older home that has stood the test of several severe natural disasters. Also, two inactive hurricane seasons, despite being forecast as active, are likely to desensitize consumer concerns about building safety. Finally, the financial impact of ever-increasing property prices, taxes, and insurance following the 2005 hurricane season and the availability of social insurance (efficient evacuation, National Guard protection of property) are likely to have led some consumers to a purchase decision where costs constraints overrode concerns for safety.[20]

Conclusion

This study has examined the capitalization of the 2002 Florida Building Code into house prices for the Jacksonville, Florida housing market. A hedonic pricing model was used to estimate the differential effect on house prices of the stricter 2002 Florida Building Code. The model also tested whether the stricter building code became more valuable to homebuyers after the disaster reality checks of 2004 and 2005. Results are presented for the aggregate data and for wind zones with different risk exposure. The results show that houses in the WBDR that were built under the new, stricter building code sold for about 4.68% more, on average, than houses built under the older, less strict code. For the reality check variables in the WBDR, the results showed that after the devastating storms of 2004 and 2006, the new-code premium declined and became slightly negative (at about 1%). After the 2005 hurricane season, however, the premium increased to almost 7%. After the relative calm 2006 and 2007 hurricane seasons, the premium dropped back to its original 4.68%.

The interior wind zones showed a more dramatic effect of building code. The coefficient for building code in the 110 mph zone showed a 17.7% premium for new-code homes. The post-catastrophe reality check variables showed the interesting pattern of not changing after the 2004 hurricane season but increasing after the 2005 hurricane season (to over 20%). After the relatively calm 2006 and 2007 hurricane seasons, the building code premium for this zone dropped to just under 15%. The results for the 100 mph zone showed a new-code capitalization rate of 7.63%. The reality check variables showed that, for this zone, the new-code premium decreased slightly to 6% after the 2004 hurricane season. However, after the 2005 hurricane season, the new-code premium increased to almost 10%. After the relatively calm 2006 and 2007 hurricane seasons, the building code premium dropped back to about 6%.

Endnotes

[1] Category 1–3 storms would include wind speeds up from 74 to 130 miles per hour.

[2] Given the advances in hurricane forecasting, the number of deaths from hurricanes is not significant and often caused by other circumstances (e.g., levy failure during Hurricane Katrina, bus fire while evacuating Houston prior to Hurricane Rita, or tornadoes spawned during the hurricane). For the purposes of this paper, safety refers to both the individual and his/her property.

[3] Some personal property such as family heirlooms/pictures may have intrinsic value far in excess of their economic value.

[4] Such was the argument presented by the Florida Home Builders Association as they fought the elimination of the Panhandle Exemption in the Florida Building Code (Florida Task Force, 2006).

[5] Under the new code, homeowners have three options for meeting the increased wind standards: (1) impact-resistant doors and windows that use laminated glass similar to

that found in car windshields; (2) window shutters including plywood in some areas; or (3) a reinforced roof that will not become detached should wind enter the home.

[6] See http://growth-management.alachuacounty.us/building/buildcode.php.

[7] Since this was to be enforced by local governments, some felt that Florida went from 470 local codes to one code with 470 interpretations.

[8] Recognizing that implementation of the Florida Building Code improved the ability of structures to withstand hurricanes, the 2007 Florida Legislature revised Florida statutes to require additional hurricane mitigation measures under certain conditions for residential structures built prior to the adoption of the Florida Building Code A portion of the new statute requiring a home grading scale is designed to create a uniform measurement of a property's ability to withstand the wind load from a sustained hurricane or severe storm. Any buyer of a home in the WBDR must be informed of this rating (s 627.0629 Florida Statutes).

[9] The State of Florida has recognized the importance of strengthening homes through a $250 million dollar mitigation program launched in 2006. The ''My Safe Florida Home'' program provided funding for inspections and efforts to build stronger homes.

[10] Katz and Rosen (1987) discuss the dissatisfaction of many communities with the effects of rapid, unregulated growth that occurred in the 1960s and 1970s and the resulting proliferation of land-use and environmental regulations. Although the growth in regulation occurred at all levels of government, the primary control over residential development remains in the hands of local government.

[11] A review of the literature can be found in Dumm, Sirmans, and Smersh (2009b), forthcoming.

[12] The time period between hurricane periods is in whole months.

[13] Given the forecast for heightened hurricane activity during the 2006 hurricane season (frequency and storm strength) and the corresponding impact on consumer expectations, the third post period extends across a time period where hurricane expectations/forecasts (high) did not align with actual experience in Florida (no hurricanes).

[14] The State of Florida WBDR map is a contour map of maximum wind speeds in miles per hour (mph) at 33 feet (10 meters) above the ground. It is produced by the Florida Department of Community Affairs (DCA), which oversees the Florida Building Code. FEMA maps are concerned with flood zones, and thus are primarily contour maps of elevation. The WBDR map is a better measure of hurricane risk because it concerns wind speed from a hurricane. While there is also flood risk in a hurricane, it is mostly from storm surge along the coastline, and not in the inland low-lying areas that are measured in FEMA maps.

[15] The coastline is segmented into one mile points and distance is calculated as the shortest distance from the property to the nearest coastal point.

[16] Other externality variables were tested for each wind zone including proximity to CBD. Based on high correlation among the variables (especially with the distance variable), these variables were not included in the final model.

[17] The Breusch-Pagan test was used to test the hypothesis of equal variances. Based on the test statistic, the hypothesis was rejected (indicating the presence of heteroscedacticity). The standard errors in Exhibit 4 are now heteroscedasticity-consistent (HC3) following McKinnon and White (1985) and Hayes and Cai (2007).

[18] Due to the high correlation between distance and the wind zone variables, only the wind zone variables are included in the aggregate model. A distance variable is included in the individual zone models.

[19] The regression model was also estimated by year and the overall results are similar to those for the aggregate model. The building code premium decreases slightly for the year 2005 and increases for the year 2006.

[20] ''At a time when many Florida property owners were experiencing significant increases in property taxes given the real estate boom, losses from the 2004 and 2005 hurricane seasons added to that burden in the form of substantial increases in property insurance premiums and the fears regarding future hurricanes,'' (Hielscher, 2006).

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