THE CAPITALIZATION OF STRICTER BUILDING CODES IN MIAMI, FLORIDA HOUSE PRICES

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I. Introduction

Hurricane Andrew, which destroyed parts of southeastern part of Florida in August 1992, was at that time the costliest natural disaster in U.S. history. At least fifteen deaths were attributed directly to the storm, 175,000 people were left homeless, 25,000 homes were destroyed, and 100,000 homes were damaged. Insurance claims totaled over $16 billion (Fronstin and Holtmann, 1994). A contributing factor for the extensive damage was felt to be the erosion of building codes in the years leading up to the storm. Fronstin and Holtman (1994) find, for homes built before Hurricane Andrew, that newer homes (built under more relaxed building codes) suffered proportionately more damage than older homes (built under stricter codes). They explain this finding by hypothesizing that consumers substituted homeowners insurance for structural soundness. After Hurricane Andrew, Broward and Dade counties passed tough new building codes (then known as the South Florida Building Code) which became effective on September 1, 1994. Among other things, requirements for the new building code included thicker plywood, impact resistant glass or hurricane shutters, and truss tie-downs with minimum uplift force of 700 pounds.

Following Hurricane Andrew in 1992, the next hurricane-related losses of catastrophic proportions occurred over a seven-week period beginning in mid-August 2004. During that time, four hurricanes made landfall in the southern U.S. resulting in a substantial number of deaths and billions of dollars in damage to residential and commercial properties. Florida was the only state to be directly impacted by all four hurricanes. On August 13, Hurricane Charley made landfall in the southwestern part of Florida as a category four hurricane. It crossed the state just south of Orlando and caused losses in excess of $10 billion. Three weeks later, on Labor Day weekend, Hurricane Francis made landfall. Although not a major hurricane (category 2), Hurricane Francis caused damage over a wide geographical area and caused approximately $8 billion in losses. On September 16 Hurricane Ivan came ashore as a category 4 hurricane. It was followed on September 26, by Hurricane Jeanne that came ashore as a category 3 storm. Losses from these two hurricanes were in excess of $6 billion. Overall, reinsurers Swiss Re and Munich Re estimated that the 2004 hurricane season (the four hurricanes noted above and Tropical Storm Bonnie) represented more than two million claims. Total insured losses in Florida in 2004 exceeded $25 billion (Florida Office of Insurance Regulation, 2006)

In August of the following year, Hurricane Katrina made landfall in Florida as a category one storm. While it did not cause substantial damage in Florida, the hurricane strengthened over the Gulf of Mexico and was a category three storm when it made landfall near New Orleans, Louisiana. Catastrophic losses from wind, storm surge, and flooding resulted in Hurricane Katrina being the costliest hurricane ever with losses in excess of $81 billion (unadjusted for inflation) (Blake et al, 2007). In loss of life, it was the third worst hurricane in U.S. history with 1500 deaths attributed to the storm (Blake et al, 2007). As with 2004, the 2005 hurricane season, based on landfalls of major hurricanes (category 3, 4, or 5), also was a highly active one. In addition to Hurricane Katrina noted above, Hurricanes Rita, Wilma, and Dennis made landfall in Florida in 2005 but unlike Hurricane Katrina, they did so as major hurricanes (category three or greater). Insured losses in Florida from the four hurricanes were in excess of $10.8 billion (Florida Office of Insurance Regulation, 2006). Total insured losses in Florida from the 2004 and 2005 hurricane seasons were approximately $36 billion (Florida Office of Insurance Regulation, 2006).

The losses from the 2004 and 2005 hurricane seasons had a severe impact on the housing stock in Florida. For example, the Insurance Information Institute (2004) estimated that one-fifth of homes in Florida were damaged by the 2004 hurricanes. Hurricane Charley alone destroyed 12,000 homes and left another 19,000 uninhabitable.

Although significant, the total damage was reduced because of stricter building codes instituted after Hurricane Andrew. Research shows that newer homes built under tougher building codes perform better in hurricanes. A 2007 study by the Tampa-based Institute for Business and Home Safety, in conjunction with researchers at the University of Florida and the FEMA Mitigation Assessment Team, examined the damage caused by Hurricane Charley and showed that newer homes suffered less damage than older homes, and their owners filed fewer insurance claims. Homes built before 1996 suffered an average loss of $24 per square foot whereas houses built between 1996 and 2004 suffered an average loss of $14 per square foot. One insurance company reported a 60 percent drop in claims for homes constructed under the newer building codes. In addition, a greater proportion of newer homes needed only minor repairs such as partial roof replacement and window screen replacement. After surveying the damage caused by a string of tornadoes that occurred in central Florida on February 2, 2007, Larry Tanner of the Texas Tech University's Wind Science and Engineering Research Center reported on terradaily.com that stronger, wind-mitigating building codes implemented after hurricane Andrew helped some newly built homes survive these devastating storms (terradaily.com, February 26, 2007).

While houses built after the implementation of the stronger building codes in South Florida could be presumed to be "safer" based on previous research, no study has measured the extent to which these stricter building codes are valued by consumers. This study addresses this issue by using a hedonic pricing model to measure the capitalization of the stricter building codes into house prices. Also, the study examines whether homebuyers attached greater value to the stricter building codes after the "reality check" of the 2004 and 2005 hurricane seasons.

II. Consumers, Disaster Mitigation, and Building Codes

As Dehring (2006b) notes, building codes have a history of over 100 years in the United States. The first model code was published by the National Board of Fire Underwriters in 1905. The value of the building code is the benefit of reduced loss of life and property damage relative to the technological and enforcement costs. As Dehring (2006b) discusses, residential construction building codes are justified for at least two reasons: (1) to correct information asymmetries where the homebuyer lacks sufficient expertise to gauge the structural integrity of the house and (2) to prevent externalities that may endanger adjacent properties.

When disaster strikes, a typical response is to tighten building codes in disaster-prone areas. As such, the primary questions of interest in this study are:

- Are consumers willing to pay a premium for safety when purchasing homes in areas prone to catastrophic wind loss?
- If so, does time proximity with catastrophic losses matter?

As such, if consumers are willing to pay a premium for safety, then purchase price decisions are expected to be, at least in part, a function of the level of perceived risk and individual risk tolerance. Questions related to risk perception and tolerance/preference have been and continue to be areas of interest for researchers. For example, risk aversion is one of the main explanations provided in the insurance economics literature as to why an individuals purchase insurance even though the premium costs exceed the charges for the pure insurance protection (expected loss). Studies evaluating safety and costs (e.g., Andersson, 2005) indicate that some consumers are willing to pay a "safety premium" for features such as side airbags when purchasing auto insurance.

For this study, the more specific question is whether, ceteris paribus, consumers will pay more for homes that are built under a higher building code standard. The stronger construction of these homes would allow them to better withstand higher wind speeds relative to homes built under a weaker building code. In this setting, the notion of preference for safety (i.e. protection from loss of life or serious injury) may be expanded to also include protection against loss of personal property (some of which may have substantial intrinsic value to the homeowner) and loss of the use of property for a substantial length of time.

Research by Meyer (2005) and others note that perceived risk is not constant and is impacted both by events and the length of time between events. Some participants in the home building industry have argued that consumers are not willing to pay extra for safety. This 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).

In related research, it has been documented that consumers do recognize and value safety. For example, builders have resisted creating safe rooms in homes in tornado-prone areas because of higher costs. Following catastrophic loss (lives and property) from tornadoes in Oklahoma in 1999, the Oklahoma Saferoom Initiative was created to increase consumer awareness about the protection provided by internal shelters. Simmons and Sutter (2007a) review purchase activity in the Oklahoma City area and the results suggest that consumers are willing to pay a safety premium for internal shelters. They also found that the initiative, along with prior tornado losses, had an impact on consumer purchase behavior and on the willingness of some builders to include this more expensive feature in the new homes that they were building. The authors find that the presence of an internal or in-home shelter resulted in a 4 percent price premium, or an increase in the median sale price of $4200 compared with an average shelter cost of $2500 to $3000. Thus, the cost of mitigation was covered by the increase in the price that consumers were willing to pay for a higher level of safety.

This study extends the work done by Simmons and Sutter, but there are substantial differences between the two extreme wind events of tornadoes and hurricanes. They differ significantly based on the size (spread) of the storm, since tornadoes impact on a much smaller area (e.g. one-half mile) while hurricanes can cover a much larger area (e.g., 75 mile diameter). Hurricanes move much more slowly than tornadoes and thus are much more predictable as to presence and direction. Modern satellite and computer technology and greater availability of weather data allow weather forecasters to provide warnings days in advance of potential hurricane landfall and this has led to a substantial reduction in loss of life from hurricanes. In fact, tornadoes spawned by hurricanes often are responsible for many of deaths that occur during a hurricane.[1] As such, consumers living in a hurricane-prone region may perceive catastrophic risk differently than consumers living in an area prone to tornado activity.

The public policy implications surrounding building codes for policy makers, insurers, lenders, regulators, and consumers in the State of Florida are significant. The positive impact of building code changes following Hurricane Andrew, mitigation, and the need to extend tougher building code standards to the Panhandle region of Florida were among the findings of the 2006 Task Force on Long-term Solutions to the Florida Property Insurance Market.

> "It is imperative that any program focus strongly on ensuring that homes in Florida are wind resistant through mitigation, which is defined as a construction activity that fortifies or hardens the envelope of residential structures by using a variety of techniques. Strong, enforced building codes are the foundation for a sustainable market for Floridians." (Task Force on Long-Term Solutions for Florida's Hurricane Insurance Market Report, page 4).

While the specific recommendation was to eliminate the Panhandle exemption and thus extend tougher building code standards throughout the state, these findings in part reflect the fact that the mitigation measures required in the building codes (e.g. hurricane roofing straps, longer roofing nails, closer spacing for roofing nails) are effective in reducing damage to the structure. As noted earlier, stronger homes not only reduce expected loss costs from hurricanes, but they also reduce potential loss of life, loss of items of significant personal value (e.g., family photographs or other heirlooms that are easily damaged or destroyed), and minimize major disruptions for family in the event the home is uninhabitable for a length of time following a hurricane loss.

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. Given the substantial increase in homeowner premiums since the 2004 hurricane season, insurance credits for mitigation are becoming increasingly important in the attempt to lower homeowner insurance premiums. Public policy makers have received many suggestions regarding ways to improve the property insurance marketplace in Florida and several are related to improving building stock. As such, it becomes even more important to

[1] The recent exception was Hurricane Katrina where many people lost their lives due to the storm surge and flooding following the failure of the levees surrounding New Orleans.

understand consumer preferences for stronger and safer homes and their willingness to spend additional money for higher levels of safety. For example, a finding of a strong preference for safe structures among consumers provides some impetus for increased direct and indirect government action or legislation beyond marginal improvement to existing building code or consumer support programs.

While the importance of superior building codes and the related mitigation efforts are intuitive, it is less clear that consumers place the same value on these efforts as do public policy makers and insurers. In a 2005 essay that evaluates the psychology of preparedness, Robert Meyer discusses how the concept of limited recall impacts disaster preparedness (Meyer 2005). This notion explains why people, based on individual experiences over a set period of time, do or do not pursue efforts to harden their homes. As such, the individual's perception of and aversion to risk during a period of low hurricane activity may be lower than it would be following a period of heightened hurricane activity. It can be argued that this perception of risk should be reflected in the premium that the buyer is willing to pay for a safer home and that this safety premium should change over time. For periods of low catastrophic hurricane loss, that risk premium for the majority of consumers could be zero. For periods of heightened activity, one would expect the risk premium to increase as the perceived risk increases. Discussing this paper at the first Florida Catastrophic Storm Risk Management Center Speaker Series on March 6, 2008, Meyer suggested that the consumer's sense of risk oscillates between these two extremes driven by the most recent activity.

III. Literature Review

Mitigation against disaster, including hurricanes, is a complex issue. First, consumers must recognize and value safety. Then, consumers must be willing to pay a premium for safety and to bear the cost of mitigation. The question becomes "what disaster mitigation measures do consumers value and what are they willing to pay for those?" The specific interest in this study is consumer attitudes toward building codes and whether stronger building codes become more valuable to consumers following a natural disaster. To fully understand the issues, a wide range of literature is reviewed and includes studies on (1) consumers' attitudes toward recognition of risk, their demand for safety, and their willingness to pay for mitigation, (2) building code regulations and housing, (3) the cost effectiveness and price effects of disaster mitigation through tornado shelters, and (4) the determinants of residential property damage caused by hurricane disaster.

A. The Demand for Insurance and Disaster Mitigation

Ehrlich and Becker (1972) provide an early discussion of the interaction between market insurance and self-insurance. They develop a theory of demand for insurance that emphasizes the interaction between market insurance, “self-insurance”, and “self-protection”. They define self-insurance as “a reduction in the size of the loss” and self-protection as “a reduction in the probability of a loss”. Using a state preference approach to behavior under uncertainty, they show market insurance and self-insurance to be substitutes. They argue that this occurs because an increase in the slope of the budget line would decrease the demand for market insurance and increase the demand for self-insurance. They also argue that self-insurance is likely to create a moral hazard since its cost is independent of the probability of hazard and expenditures on self-protection. As a result, they argue, the availability of self-insurance would discourage self-protection and vice versa.

A later study by Shogren, Shin, Hayes, and Kliebenstein (1994) examines the relationship between willingness to pay (WTP) and willingness to accept (WTA) for identical goods. They hypothesize that convergence of WTP and WTA value occurs between two goods that are very close substitutes. Subjects participated in a two-stage experiment of willingness to pay and willingness to accept. The authors find that, for two private market goods with relatively close substitutes, the divergence of WTP and WTA values disappears with repeated exposure to the market.

From a health perspective, Viscusi (1994) examines how the costs of risk regulation affect health investment and mortality. He argues that, although risk regulations directly reduce risk, an offsetting risk is generated by a reduction in individuals’ risk-averting actions (a substitution effect). This is important because these effects alter benefit-cost criteria and the value-of-life estimates. He finds that the effect of risk regulation on safety diminishes the incentive for individuals to invest in health because greater safety levels in the workplace and personal health investments are substitutes from the standpoint of increasing one’s longevity. Additionally, increases in regulatory costs are equivalent to a decrease in income, which, in turn, decreases investments in health. However, he did find that increases in income lead to investments in one’s health.

More recent studies address property disaster mitigation. Kunreuther (1996) examines the lack of willingness by homeowners to purchase insurance and/or to adopt cost-effective protective measures against disaster. His study focuses on the “natural disaster syndrome” which consists of individuals’ limited interest in protection prior to a disaster and the resulting high costs to insurers and governments following a disaster. He posits two reasons for the reluctance to invest in loss prevention: (1) individuals underestimate the probability of a disaster and (2) future benefits are discounted at such high discount rates that they have a small present value relative to costs. Other factors that affect the decision to not purchase or cancel existing insurance include (1) the importance of the perceived risk, (2) the automatic assumption that governmental aid will be forthcoming following a disaster, and (3) a lengthy period of coverage without losses. He concludes that insurance would serve as a much better policy tool to reduce future losses if it were linked to well-enforced building codes. He argues that, although hurricanes can be life threatening, emergency management policy has dramatically reduced the loss of life from severe storms. As a result, consumers view hurricane mitigation as a property protection issue rather than a life safety issue.

Ozdemir and Kruse (2000) use socioeconomic variables to examine the relationship between consumers' risk perception and their willingness to pay for increased safety in catastrophic events, specifically a storm shelter. Using a survey questionnaire, the authors measure risk perception by using (1) a risk ladder that measures risk in terms of mortality probabilities and (2) the probability of exposure and relative severity. The authors conclude that the risk ladder measure is not adequate in measuring risk perception since they find no significant relationship between the risk ladder measure and the willingness to pay. They also conclude that the decision to invest in a storm shelter is determined by perceived risk exposure and the presence of children in the household.

B. The Demand for Safety and Mitigation Efforts

Some studies have examined the demand for safety and the willingness to invest in mitigation efforts. Meyer (2005) reviews the state of knowledge concerning market attitudes relative to mitigation-making decisions against low-probability, high-consequence events. Drawing from a series of laboratory studies at Wharton after Hurricane Katrina, the study examines issues such as the pricing of protection. Meyer argues that three biases prevent consumers from making optimal mitigation decisions: (1) relying on short-term feedback for learning (the consumer may have no immediate recollection of instances of disaster), (2) seeing the future as an extrapolation of the present, and (3) an attitude that discounts the value of ambiguous future returns relative to short-term costs. He also argues that consumers' reluctance to invest in mitigation results from a combination of three factors: (1) misperceptions relative to personal risk exposure, (2) misperceptions regarding the severity of disasters, and (3) procrastination in implementing mitigation (when faced with choosing options whose benefits are uncertain consumers will often default to doing nothing).

Miller, Morgan, and Womack (2002) examine the demand for tornado saferooms and compare the amount consumers are able and willing to pay for a saferoom relative to the cost of producing it. They utilize a survey conducted in Tulsa, Oklahoma and include two locations: (1) houses without saferooms in a distressed urban area in the early stages of rehabilitation and (2) a new suburban housing development that required the inclusion of a saferoom. The survey questioned consumers relative to experience with tornadoes, the perceived effectiveness of saferooms, and the perceived responsibility of protecting one's family. The results from their regression models show that consumers perceive saferooms as beneficial and effective. However, the price that consumers were willing to pay for a saferoom was less than the cost. Also, interestingly, primary variables such as income and tornado experience were not significant in determining the demand of saferooms.

Sadowski and Sutter (2008) examine mitigation efforts based on both public policy and individual responses to a hurricane. They argue that, if mitigation efforts are increased following a disaster, locations with prior hurricane landfalls should suffer less damage. The authors analyze landfalling hurricanes in the U.S. between 1950 and 1999. Using only major hurricanes, they find that mitigation did not reduce damage. They attribute this result to pressure to rebuild quickly and thus a lack of opportunity to implement new building codes or other mitigation techniques. The authors do find a significant reduction in current damages when a prior hurricane had struck 10 or more years earlier. They argue that this results from a sufficient time having passed for mitigation to take hold. This result is explained as the time needed for mitigation to become effective, as construction occurs slowly.

C. The Effectiveness of Mitigation Efforts

Several studies have examined the effectiveness of different types of mitigation efforts. Peltzman (1975) examines the effects of automobile safety regulations on highway deaths. Using accident rates before regulation, he calculates estimates of accident rates during the regulation period that would have been expected without regulation. While previous studies have suggested that annual highway deaths would be 20 percent greater without legally mandated installation of various safety devices on automobiles, Peltzman concludes that safety regulation has had no effect on highway deaths. Instead, he argues that the decline in the death rate is more attributable to factors such as: (1) a tapering of the influence of the postwar baby boom on the age distribution of drivers, (2) more normal growth of the price of leisure, (3) more normal growth of vehicle speed and (4) a rise in the cost of accidents (insurance costs, health care, and auto repair costs have increased faster than other consumer prices).

A more recent study by Simmons, Kruse, and Smith (2002) examines the price effects of voluntary mitigation measures by home owners to protect their properties. It is assumed that mitigation efforts can reduce the size of the loss (severity) and/or reduce the probability of the loss (frequency). Using single-family home data for a Gulf Coast city, the authors examine the effect of two mitigation efforts on house prices: storm shutters and structural integrity. They construct a structural integrity index based on topographical location, structural characteristics, and architectural features of the house to measure the likelihood that the home may survive a severe windstorm. Their results show that both mitigation variables have a positive effect on selling price, with the presence of storm shutters adding about 5 percent to the selling price. The authors conclude that, contrary to the notion that homeowners will not voluntarily adopt disaster mitigation measures, individuals place a positive value on self-insurance type of mitigation.

D. The Effect of Changes in Code Regulations

Several studies have examined the effect of changes in building code regulation on housing. An early study by Oster and Quigley (1977) examines the factors that affect the diffusion of improved building techniques in residential construction. They find that factors such as the educational level of the chief building official, the extent of unionization, and the relative size of homebuilding firms affect the diffusion of innovations in residential construction.

A later study by Noam (1982) analyzes a simultaneous model of the restrictiveness of building codes on house prices and the impact of housing values on the strictness of codes. Using U.S. data for 1970 and 1,100 localities with varying degrees of building code restrictiveness, Noam's results show that house prices are positively associated with regulatory strictness and that the strictness of codes is affected by house values. His argument for a simultaneous relationship between building code and house prices is this: restrictions on land use and housing create an exclusionary environment which discourages the influx of people into high income areas. If this is the case, one might expect strict building codes to be more prevalent in areas where housing is already relatively high-priced.

Noam (1982) discusses that building codes affect house prices in several ways. First, they influence the current construction of houses and second, they affect the value of the existing housing stock by changing the supply of its replacement. He points out that the purpose of building codes is not to restrict technology but to control negative externalities of construction and to assure consumers that the homes that they own are safe and sanitary. Further, stricter codes would tend to reduce cost-efficiency in housing construction, making it more expensive. Because of the existence of a positive cross-elasticity of demand between new and existing housing, the value of the existing housing stock would be expected to appreciate.

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. The authors describe how zoning and subdivision ordinances, building codes, and land-use plans are major tools for the regulation of new development.

More recent studies by Dehring and Halek (2006) and Dehring (2006) examine coastal building code regulations. Dehring and Halek (2006) examine whether the magnitude of hurricane damage to residential properties is related to the building code under which the property was constructed. They find that properties built under code changes associated with the National Flood Insurance Program were more likely to sustain damage relative to similarly located properties built prior to the National Flood Insurance Program. For damaged properties, the extent of damage was greater for post-NFIP construction. The authors suggest that wind or flood (or a combination of the two) were the likely causes of damage. Their findings raise concerns regarding the effectiveness of federal and state mandated coastal building codes.

Dehring (2006) examines the effect on land prices for three changes in coastal building regulations for Florida's barrier islands. She uses data for five barrier islands in Lee County to estimate a hedonic pricing model. Her results show that land values decrease in response to the county's participation in the National Flood Insurance Program, the establishment of a Coastal Building Zone, and the re-establishment of the Coastal Construction Control Line. She concludes that the benefits of safety from increased building standards are outweighed by the additional costs of compliance.

A recent study by Bin, Kruse, and Landry (2008) examines the effects of flood hazard on coastal property values. Examining the effects of differential flood risks on property values is problematic because, as the authors point out, natural hazards are correlated with spatial amenities. 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. This positive correlation between risk and spatial amenities can bias estimates of risk trade offs downward if amenities are not controlled. Also, spatial dependence arises because residential properties sharing common features tend to cluster in space. If the relevant spatial dependence is ignored in estimation of the hedonic price function, the resulting estimates could be inefficient or even inconsistent. As a result, the authors create a spatial weights matrix that defines a "neighborhood set" for each observation. They then estimate spatial autoregressive error models via maximum likelihood.

The authors estimate a hedonic pricing model of the effects of flood hazard on coastal property values using real estate transactions from 2000 to 2004 in North Carolina and GIS on flood zones. Information on flood hazard, coastal amenities, and standard structural/neighborhood attributes were available for 3,106 sales. The results show that location within a flood zone lowers property value by an average of 7.3 percent. The authors also calculate flood insurance premiums and compare capitalized insurance premiums with sales price differentials. They find that the sale price differentials are larger than the capitalized insurance premiums for high-priced homes. The results are opposite for lower-priced homes. This suggests that, for higher-priced homes, nonmonetary losses cannot be covered by insurance. Overall, the results support the conclusion that flood zone designation and insurance premiums convey risk information to potential buyers in the coastal housing market. Although these authors' focus is on flooding, the coastal concentration issue equally applies to windstorm risks.

E. The Capitalization of Tornado Shelters

K. M. Simmons and D. Sutter have published several papers examining the cost effectiveness and price effects of disaster mitigation through tornado shelters. In a 2006 paper, they discuss how tornado shelters provide self-protection because they reduce the probability of casualties during a tornado but they do not reduce the probability of a tornado occurring. Understanding that the probability of a tornado at a household's location does not vary over time, the household must place a value on the prospect of a fatality or injury in order to estimate the expected benefits of a shelter purchase. The authors provide a direct estimation of the benefits of tornado shelters using the probability of a tornado at a specific location and the probability of a casualty without a shelter. They provide an alternative estimate of the value of tornado shelters based on a measure of tornado risk, not only the combined effect of risk and precautions. Their results show that shelters provide cost-effective protection for mobile homes but not for permanent homes.

Simmons and Sutter (2007a) examine the capitalization of tornado shelters in house prices. Using Oklahoma City data for 2005, the authors find that, on average, a shelter increases the selling price of a house by about 4 percent or about $4,200 (based on the mean price of homes sold in 2005). They argue that the capitalization of mitigation into house price is essential to create incentives for homeowners to invest in mitigation.

Simmons and Sutter (2007b) examine the effect on rents of tornado shelters in mobile home parks. The authors find that rents for lots in parks with shelters are 5 to 8 percent higher. This additional rent is approximately sufficient to cover the cost of shelters.

F. Residential Property Damage Caused by Hurricane Disaster

Fronstin and Holtmann (1994) examine the determinants of residential property damage caused by Hurricane Andrew in south Florida in 1992. They observe that subdivisions built in the late 1960s incurred the least amount of damage but after 1970 the percentage of uninhabitable homes significantly increased within the lowest wind speed category. They find that very new subdivisions suffered a large amount of damage regardless of the wind speed during the hurricane. They also find that wind speed was not the only factor that caused severe destruction. Other factors included low quality construction, faulty designs, and flimsy materials (more common in new dwellings). They argue that these factors were a result of an eroding building code beginning in the 1970s.

Using data for subdivisions and condominiums in southeast Florida, the authors estimate a two-limit Tobit model where the dependent variable is “the percentage of homes in a particular subdivision that were declared uninhabitable.” Their results suggest that the value of a home is a significant indicator of the ability to withstand the force of a hurricane in that homes with lower assessed value were more likely to be uninhabitable after the storm. The results suggest that, because of less stringent building codes, newer homes suffered significant damage regardless of wind speed and were more likely to be destroyed. The authors present various reasons why newer homes suffered more damage. These include

1. A decline in building codes beginning in the 1970s.
2. Consumers finding it more cost effective to substitute homeowners insurance for quality construction and structurally sound homes.
3. Evacuation being less expensive and more efficient. This meant that there might be property damage but the probability of loss of life was decreased.
4. Cheaper inputs in housing construction meant lower cost. Apparently buyers favored product characteristics over solid construction. They were more willing to pay for the former.

5. Social insurance was readily available in the form of low interest rebuilding loans and National Guard protection of property. This reduced the incentive for homeowners to remain in a threatened area to protect their property.

The authors conclude that the deterioration of standards may be nothing more than the moral hazard problems associated with many types of insurance. In the case of this storm, consumers who knew their properties were insured and were able to evacuate safely were more willing to leave their property. An interesting question is why insurance companies underwrote policies with such complete coverage in the face of growing problems of deteriorating housing code protection. The authors conclude that, according to industry experts, it was lack of experience with hurricanes of great magnitude.

G. Summary of Literature Relative to the Value of Building Codes

Although the mitigation literature is varied, inferences can be made as to the value (perceived or actual) of building codes. A majority of the literature shows that, for various reasons, consumers are more likely to not place a high value on building mitigation. The following is a summary.

Study	Reasons for not Valuing Building Codes
Ehrlich and Becker (1972)	Moral hazard of self-insurance
Kunreuther (1996)	Ability to substitute insurance for mitigation and the low present value of future benefits of mitigation
Meyer (2005)	Consumers' short-term memories and perceptions regarding personal safety and the severity of disasters
Sadowski and Sutter (2008)	Empirical results show that mitigation does not reduce damage in disasters
Dehring and Halek (2006)	Properties under national flood program were more likely to sustain damage
Dehring (2006a)	Empirical results show that the cost of compliance for national flood program outweighed the benefits of safety
Fronstin and Holtmann (1994)	Availability of social insurance (low-interest loans, National Guard protection of property, etc.), ability to substitute insurance for mitigation, and efficient evacuation procedures.

A few studies support the concept of a positive value of building codes. These are summarized below.

Study	Reasons for Valuing Building Code
Miller, Morgan, and Womack (2002)	Consumers' perceived effectiveness of saferooms as protection against tornadoes and the perceived responsibility to protect one's family
Simmons, Kruse, and Smith (2002)	Empirical results show that mitigation variables (storm shutters, structural integrity index) have a positive effect on selling price
Noam (1982)	Empirical results show that house prices are affected by the strictness of building codes.

IV. Data and Research Methodology

Previous studies have examined the effect of land-use regulation on house prices by looking at the effect of zoning and growth control laws. Examples are the previously discussed papers by Katz and Rosen (1987) and Oster and Quigley (1977). Few studies, however, have examined building codes and, for those that have, most have been concerned with the effect of the code on construction costs and rehabilitation incentives. For example, a recent study by Mattera (2006) discusses the flexibility in the new "rehab codes", making possible the rehabilitation of core urban areas. Other examples are Noam (1982), Dehring and Halek (2006), and Dehring (2006). The study will examine directly the effect of a change in building codes on house prices. It will also examine whether consumers' perceptions of building codes are changed after major catastrophic events.

A. The Empirical Model

In explaining house prices, the real estate literature has typically used hedonic regression analysis to identify the marginal effect on house prices of various housing characteristics. Sirmans, Macpherson and Zietz (2005) examine hedonic pricing models for more than 125 empirical studies and find that these studies have examined a vast number of variables. However, a change in building code has not been one of them.

Generally, the hedonic pricing model takes the form

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

where selling price (sp) is expressed in logged form, 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 (e.g. structural and locational) for property j, and ε_i is the residual error term.

To examine the effect of the change in building code, the hedonic model is expanded to include a variable to account for the building code under which a given house is built. To the extent that consumers value safety and disaster mitigation (Simmons and Sutter (2007) for example), the results should show houses built under the stricter building code selling for higher prices relative to houses built under the less strict code, everything else held constant.

Variables are also included in the model to measure whether the 2004 and 2005 hurricanes were a "reality check" and whether they raised building code awareness for home buyers. These variables will 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 and increased the desire for safety, the houses with stricter building codes would be expected to sell for higher prices relative to houses with the less-strict code.

With the additional variables, the hedonic model now becomes:

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

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 1994 stricter building code change 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 older code and the newer, more strict building code. To the degree that consumers value disaster mitigation (Simmons and Sutter (2007) for example), the expected coefficient on $Bldgcode_j$ would be positive.

$BldgcodePostH1_j$, $BldgcodePostH2_j$, and $BldgcodePostH3_j$ are interactive 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 October 2004 through June 2005. This is the time between the last hurricane of 2004 and the first hurricane of 2005.[2] $BldgcodePostH2_j$ represents houses built under the new code that sold November 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 2007).[3] These variables will test whether the "reality checks" of the 2004 and 2005 hurricanes increased consumers' awareness of building codes in the form of higher prices for homes built under the stricter code. To the extent that a recent disaster creates a greater desire for disaster mitigation, the coefficients on the interaction variables would be expected to be positive.

B. The Data

The model is estimated using owner-occupied, single-family homes in Miami-Dade County. Data are available on individual parcels of property and contain information regarding structural characteristics (e.g. square footage), lot size, year built, and most recent selling price and date for each parcel.[4] To determine location, Geographic Information System (GIS) map coverage's of parcel boundaries are also available.

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

[3] 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).

[4] The original source of the sales data is the Miami-Dade County Tax Collector's office; however, this data is sold by Enterprise Technology Services. This firm also sells a Property Master Database (which contains variables such as building size, lot size, and the year that the building was initially constructed), a Building Database (which contains variables such as number of bedrooms, number of bathrooms, effective age of the building, and extra features such as air conditioning and pool), and a GIS database. Data from these different databases was joined together using the parcel identification number.

Using GIS, the property parcel map is overlaid on the hazard modeling map to determine locational risk for each parcel. The data are divided into three zones.[5] Zone 1 includes houses that are within 1,500 feet of the coast. These homes are within the Storm Surge Coastal Control Line and would be exposed to extreme hurricane risk including winds greater than 150 miles per hour. Zone 2 includes properties that are more than 1,500 feet from the coast but within ten miles of the coast. These houses fall within the 140 MPH wind contour and would have less risk exposure but would still be subject to extreme conditions. Zone 3 includes properties that are located on the leeward side of the wind contour. These houses would be expected to have a somewhat lower risk exposure than properties located in Zones 1 and 2.[6]

The final data set contains 57,100 home sales and includes those houses that were built between 1970 and 2007. Fronstin and Holtmann (1994) have shown that homes built after 1970 had significantly increased damage during Hurricane Andrew than homes built in the 1960s and before. They attribute this to lower quality construction, faulty design, and flimsy materials resulting from an eroding of building codes in south Florida beginning in the 1970s. To provide more consistent results, those houses that were built before 1970 are excluded from the sample.

B.1. Housing in Miami-Dade County

Data on real property in Miami-Dade is available on CD from Enterprise Technology Services. There are approximately 770,000 records on the entire file that includes all parcels. Of these, approximately 370,000 records are single-family detached houses. There are four separate databases containing different types of property information – these can be appended to each other using the parcel identification number. Brief descriptions of the databases (and fields of interest) are as follows:

Property Master Database

FOLIO	parcel identification number
SLUC	state land use code (single family is 0100)
BLDG_SQFT	size of the building in square feet
LOT_SIZE	size of the land in square feet

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[5] This map is the State of Florida Wind-Borne Debris Region map. It is a contour map of maximum wind speeds in miles per hour (mph) at 33 feet (10m) 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 Wind-Borne Debris Region 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.

[6] It would have been appealing to include a measure of whether a house was right on the water. However, there was no variable measuring this in the data and one could not be created using GIS. We do feel that using the commonly accepted "zones" adequately measures location for the purposes of this study.

YR_BUILT	year that the building was initially constructed
TOTAL_VAL	current assessed value of the property
HEX_VAL	homestead exemption (indicates if property is owner occupied)

Building Database

FOLIO	parcel identification number
BED	number of bedrooms
BATH	number of bathrooms
FLOORS	number of floors
BLDG_SQFT	size of the building in square feet
LOT_SIZE	size of the land in square feet
YR_BUILT	year that the building was initially constructed
EFF_AGE	effective age of the building (due to remodeling)
XFEA	extra features such as air conditioning and pool

GIS Database

The GIS database is available in various formats including ArcView shape files in the State Plane coordinate system (feet) NAD83, Zone 3601 (Florida East). Fields include:

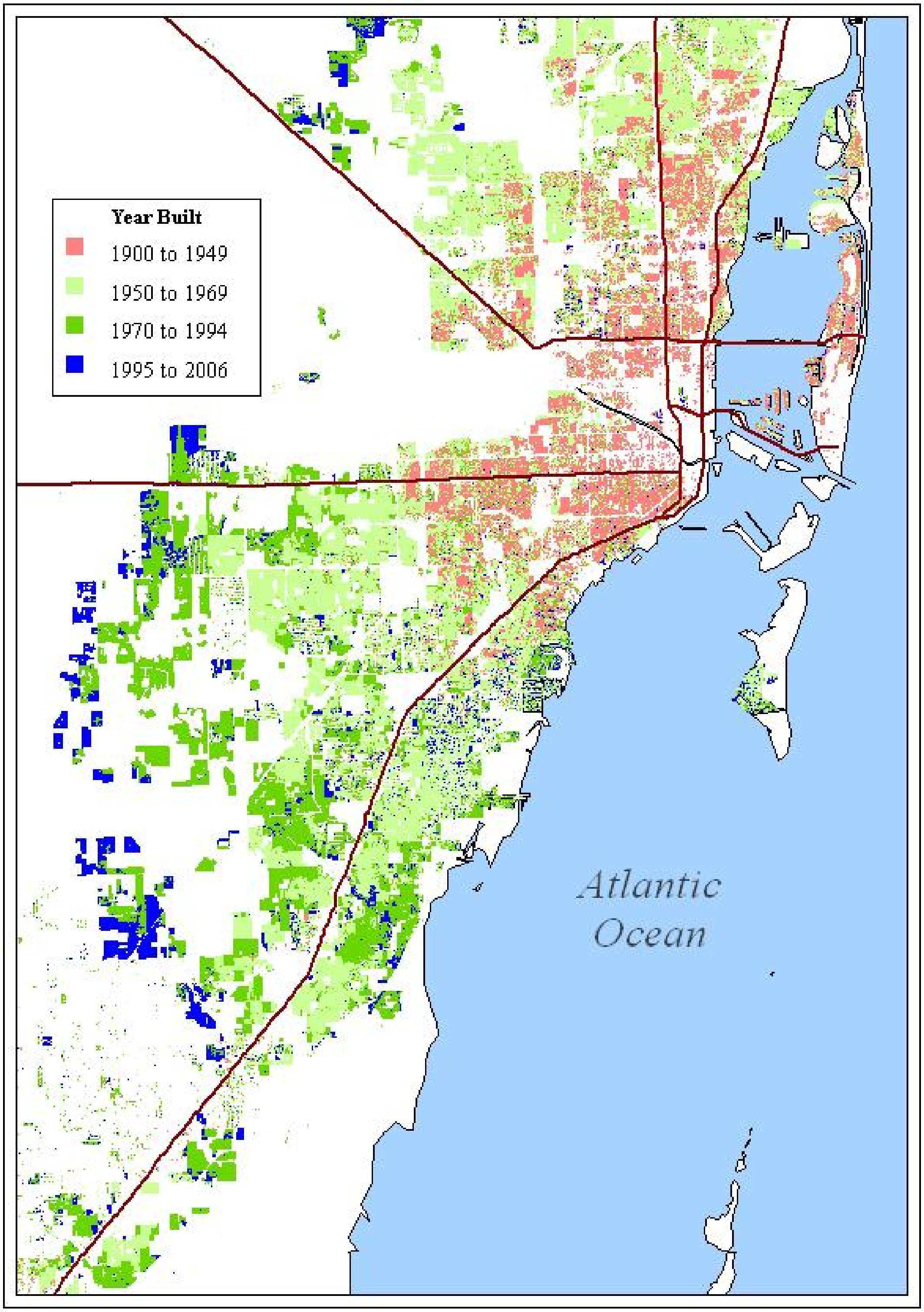
FOLIO	parcel identification number
LON	degrees west longitude
LAT	degrees north latitude
AREA	GIS calculation of parcel size

The GIS database allows the data to be mapped and analyzed – for example, Figure 1 on the following page illustrates the spatial pattern of houses by when they were built. GIS can also be used to calculate additional variables for areas in which parcels are located or distances from a line or point. For example, parcels that are within 1,500 feet of the coastline (the Special Protection Windzone) can be identified.

Map of Single Family Homes in Miami by Year Built

Figure 1 shows the spatial pattern of housing development in Miami. After Hurricane Andrew in 1992, Broward and Dade counties passed tough new building codes (then known as the South Florida Building Code) which became effective on September 1, 1994, so houses built in 1995 and later were built under the stricter building codes. Additionally, the ability to visualize the data can indicate various location variables which can be created using GIS.

Figure 1
Spatial Pattern of Houses by Year Built- Miami, Florida


Year Built
1900 to 1949
1950 to 1969
1970 to 1994
1995 to 2006
Atlantic
Ocean

Sales Master Database

FOLIO	parcel identification number
SALES_TYP1	type of most recent sale
SALES_AMT1	amount of most recent sale
SALES_MM1	month of most recent sale
SALES_YR1	year of most recent sale
SALES_TYP2	type of second most recent sale
SALES_AMT2	amount of second most recent sale
SALES_MM2	month of second most recent sale
SALES_YR2	year of second most recent sale
SALES_TYP3	type of third most recent sale
SALES_AMT3	amount of third most recent sale
SALES_MM3	month of third most recent sale
SALES_YR3	year of third most recent sale

The type of sale is a code that indicates whether or not the sale is a qualified sale. Those codes are:

0	no sale
1	good sale
2	other property involved
3	tax deed or contract deed
4	inter-family sale (quit claim)
5	government sale below market value
6	good sale but not typical of market

The sales database provides up to three sales transactions for each property. This database is split into three separate databases, which are then appended to each other to create a single database ordered by year of sale. Some houses may have no qualified sales and not be included in the database, while others could possibly have as many as three different sales in different years. Although sales volume varies by year, there are typically 10,000 to 15,000 qualified sales per year since 1990.

These databases are then combined into a single database that contains sale price and date, structural characteristics (such as house size, age, and lot size), and location characteristics (such as location within a certain area or distance from a particular point or line – for example, the distance from the coast).

B.2. Characteristics of the Data

This section contains descriptive statistics of the variables included in the estimation model. Table 1, which defines the variables included in the regression model, is shown in the Appendix along with Table 2, which provides summary statistics for the variables in the regression model. For the aggregate data, houses that sold between 2000 and 2007 had an average selling price of $343,754 with a minimum price of $50,000 and a maximum of $5,000,000. The average square footage was 2,283 and the average lot size was 11,065 square feet. The average age was 15.21 years and the average number of bathrooms was 2.28. Thirty-three percent of houses sold had a swimming pool. About 35 percent of the houses sold were built under the new building code. The average household size was 3.3 persons and the average household income was $61,614. The proportion of homes sold each year is relatively constant until 2007. The number of homes sold each season is relatively constant with slightly more homes sold in the spring and summer relative to the fall and winter.

Zone 1 contains homes sold during the 2000-2007 period and that are located within 1,500 feet of the coast, within the storm surge coastal control line. These are properties that would be exposed to the most extreme hurricane risk including winds greater than 150 miles per hour. These houses had, on average, a selling price of $1,367,996, 4,105 square feet, a lot size of 12,863 square feet, and 3.75 bathrooms. These houses were an average of 15.67 years old and 84 percent had a swimming pool. Thirty-six percent of these houses were built under the new building code. The average household size was 2.6 people and the average household income was $117,423. The proportion of homes sold each year is relatively constant until 2006 and 2007 when it decreases. The seasonal variables show that, on a proportionate basis, more homes are sold in the summer. Of the total sample of 57,100 home sales, 1,851 sales came from Zone 1.

A large proportion of the sample was located in Zone 2 (40,234 out of 57,100 home sales). Recall that Zone 2 includes properties that are more than 1,500 feet from the coast but within ten miles of the coast and would fall within the 140 MPH wind contour. Although these homes would have less risk exposure than homes in Zone 1, they would still be subject to extreme conditions. As seen, the average selling price for homes in this area ($322,791) was much less than the average price in Zone 1. They were also smaller, on average, with 2,171 square feet and were located on smaller lots. The average age for houses sold (17.06 years) in this area was greater than for houses sold in Zone 1. These houses had 2.23 bathrooms, on average, and 35 percent had a swimming pool. A smaller percentage of the houses sold in Zone 2 (32 percent) relative to Zone 1 were built under the new building code. The average household size was 3.3 persons and the average household income was $60,149. The proportion of homes sold each year is relatively constant until it decreases in 2007. On a proportionate basis, more homes are sold in the spring and summer than in the fall and winter.

Zone 3 contains 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 Zones

1 and 2. The average house price is lowest for this zone ($273,664). The houses were slightly smaller (2,171 square feet) and had slightly smaller lot sizes (10,362 square feet) relative to the other zones. These houses were, on average, 10.21 years old, much newer than homes sold in either Zone 1 or 2. They have an average of 2.24 bathrooms and 22 percent of the homes had a swimming pool. Of the 15,015 homes sold in this zone, 44 percent were built under the new building code. The average household size was 3.5 persons and the average household income was $58,663.

V. Empirical Results

The regression model is estimated for the aggregate data and for each of the three zones. The statistics show that the model is a good fit for the data and has high explanatory power. The results are discussed in this section.

A. What the Model Says About the Aggregate Data

The regression model is first applied to the aggregate data (all results are given in Table 3 in the Appendix). The housing characteristics have the expected effect on sales price. Square footage, lot size, number of baths, and swimming pool all have a positive effect on selling price. The age variable is not significant.[7] Average household size has a negative effect on selling price while household income has a positive effect. The zone variables show that house prices decrease as location moves inland from the coast. The variables Y2001 through Y2007 represent the year in which the house is sold. With Y2000 as the omitted variable, the results show that house prices increased steadily over this period with prices in 2007 being 94 percent higher than prices in 2000. The seasonal variables show that comparable houses sold for higher prices in the summer and fall relative to the winter and spring.

The variables of primary interest are those measuring the effect of building code. The variable measuring price differences between the stricter and less-strict building codes shows that, for the aggregate data, houses sold over the 2000-2007 period that were built under the stricter building code did not sell for a premium relative to houses built under the older, less strict code.

The post-catastrophe ("reality check") variables provide some interesting insight into buyer behavior. Following the 2004 hurricanes, houses built under the stricter code actually sold for less, on average, than comparable houses built under the older code. However, this negative pricing disappears after the 2005 hurricanes. This result is not surprising since South Florida experienced significant losses from the 2005 season (particularly from Hurricanes Wilma) while it experienced minimal damage in 2004. In other words, South Florida was much more directly impacted by the 2005 hurricanes than it was with the 2004 storms. Moving out of 2006 and into 2007, consumers, having dealt with the aftermath of the hurricane destruction, attached a positive premium of about 1.60 percent to homes built under the new code. This means that houses built under the new code sold for an average of 1.60 percent more than comparable houses built under the older code.

B. What the Model Says About the Coastal Zone

When the regression model is applied to houses in the coastal zone the housing characteristics variables behave as expected, all with significant, positive signs. The age variable is not significant. Household size has no effect on price but household income has a positive effect. The year variables show that house prices in this zone increased by 78 percent over the 2000-2007 period. The seasonal variables show that houses sold for higher prices in the summer and fall relative to the winter and spring.

The building code variable shows that consumers in Zone 1, those homebuyers with the greatest risk exposure, were differentiating between homes built under the new code versus the old code and were willing to pay a premium of about 10.4 percent for the stricter code. This means that houses built under the new code sold for about 10.4 percent more than comparable houses built under the older code.

The "reality check" variables for Zone 1 show that, immediately after the hurricanes of 2004, houses built under the new code did not sell for a premium. As previously noted, this could have been a function of the minimal impact of the 2004 hurricanes on the South Florida area. After the much greater impact of the 2005 hurricanes, buyers once again began attaching the 10.4 percent premium to the new code. This premium continues to be observed through 2007.

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[7] To account for the multicollinearity between age and the building code variable, a two-step method is used. First, age is regressed on the other variables in the hedonic model. Then the regression residuals between age and predicted age are included in the hedonic model. Tests show that this eliminates the correlation problem between age and building code.

C. What the Model Says About the Intermediate Zone

Applying the regression model to Zone 2, the intermediate zone, produces the expected results for the housing characteristics variables. Again, they are all positive and significant. The age variable is not significant. Household size has a negative effect on price and household income has a positive effect. The year variables show that house prices in this zone increased about 93 percent over the 2000-2007 period. The seasonal variables show that houses sold for higher prices in the summer and fall relative to the winter and spring.

The building code results for Zone 2 show that homes built under the new code sold for a small premium (0.70 percent). Thus, for this zone, the stricter building code was valued by consumers, but only marginally with stricter code houses selling for a premium of less than one percent. The post-catastrophe building code variables show that this premium disappeared after the 2004 hurricanes and that houses built under the new code actually sold for less, on average, than comparable house under the older, less strict code. After the 2005 hurricanes the small premium for the new code returns and is present in selling prices.

D. What the Model Says About the Inland Zone

For the most inland zone the housing characteristics again behave as expected with significant, positive coefficients. The age variable is not significant. Household size has a negative effect on selling price and household income has a positive effect. The year variables show that, from 2000 to 2007, house prices in this area increased by 98 percent. The seasonal variables show that prices are highest in the summer and fall.

The building code results show that homes built under the new, stricter building code sold for about 1.40 percent more, on average, than homes built under the older, less strict code. The post-catastrophe variables show that, after the 2004 hurricanes, houses built under the new code sold for slightly less (0.14 percent), on average, than houses under the old code. However, after the 2005 hurricanes, a substantial premium is observed for houses built under the new code. By 2007, the building code premium was back to about 1.40 percent.

The negative premium for building code after the 2004 hurricanes appears to be counterintuitive. The worst one might expect is that consumers would be indifferent between codes. However, the negative results are actually in line with the moral hazard problem of hurricanes and insurance discussed by Fronstin and Holtmann (1994). They discuss the ease of substituting insurance for hurricane disaster and consumers' preferences for product characteristics over solid construction.

Ease of substitution is impacted by the availability and affordability of insurance. Insurer response to 2004 losses in Florida was to increase premiums. While mitigation features were previously recognized as important in reducing loss, the losses from 2004 and 2005 provided substantial loss data that has led to more accurately and adequately reflecting the impact of mitigation in the form of premium reduction. As such, we would argue that differences in insurance premiums between older and newer homes in 2004 were not to a level that reflected the mitigation benefits of the newer home. Consumers were purchasing homes in a market undergoing rapid increase in prices at a time when other costs of home ownership (i.e., insurance and property taxes) were increasing. Without sufficient differences in insurance premiums between older and newer homes, it would appear that consumers found greater value in older homes.

In contrast, the time period following the 2005 hurricane season shows a positive premium for Zone 3 (not for the other two zones). It is in 2005 that two hurricane directly impacted Miami-Dade county (particularly Hurricane Wilma).

Despite predictions of a highly active and destructive 2006 hurricane season, no hurricanes made landfall in Florida. The same was true for 2007. The third "reality check" variable captures these two time periods where forecasts of continued heightened hurricane activity proved to be inaccurate. It also reflects the passage of time from the significant losses of Hurricane Wilma in October 2005. This variable shows no premium being paid for the stricter building code over this period. One possible explanation could be the "test of time" syndrome. A homebuyer may not see the benefit of paying as great a premium for a newer-code home (which may have fewer amenities) relative to an older home that has stood the test of several severe natural disasters. Second, two inactive hurricane seasons following forecast of heightened hurricane activity are likely to desensitize consumer concerns about building safety. Third, the financial impact of escalating property prices, taxes, and insurance costs following the 2005 hurricane season are likely to have led some consumers to a purchase decision where costs constraints overrode in part concerns for safety. [8]

[8] "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" (Heilscher, 2006).

VI. Summary

Given the fact that Florida is bordered on two sides by the Atlantic Ocean and the Gulf of Mexico, it has the highest level of exposure to hurricane risk of any coastal state. Hurricane Andrew in 1992 was the costliest natural disaster in U. S. history up to that time. The next catastrophic hurricane events in Florida occurred in 2004 and 2005. Rather than catastrophic losses from a single event as was the case with Hurricane Andrew, seven hurricanes during the 2004 and 2005 hurricane seasons resulted in total insured losses in Florida of approximately $36 billion (Florida Office of Insurance Regulation, 2006).

Florida's housing stock was, of course, severely impacted by these natural disasters. Some research has shown that homes built under tougher building code standards are more resistant to hurricanes. A major question is the willingness of homeowners to pay for the increased cost associated with more stringent building codes. Research has shown that consumers recognize and value safety and disaster mitigation (especially relative to tornado shelters). Although the importance of stronger building codes is intuitive, the value of these mitigation efforts is less clear. This study has addressed this issue.

After Hurricane Andrew in 1992, Broward and Dade (renamed Miami-Dade in 1997) counties in south Florida implemented the South Florida Building Code, a more stringent building code. While houses built after the implementation of the stronger building codes in South Florida could be presumed to be "safer" based on previous research, no study has measured the extent to which the stricter building codes are capitalized by consumers in their home buying decisions.

A hedonic pricing model was used to estimate the differential effect on house prices of the stricter 1994 South 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 were presented for the aggregate data and for individual zones of different risk exposure. The results show that houses built under the new, stricter building code sold for more, on average, than houses built under the older, less strict code. The greatest premium for building code is seen in the coastal zone, which has the greatest risk exposure. Homes built under the stricter code sold for about 10.4 percent more, on average, than comparable homes built under the old code. The interior zones also show a building code premium, although the premium is less than for the coastal zone.

The post-catastrophe ("reality check") variables provide some interesting insight into consumer behavior. For all three zones, there was a negative building code premium immediately following the

2004 hurricane season. A possible explanation is that, even though four hurricanes had an impact on Florida, the overall impact was minimal for the Miami area. This may create the “test of time” syndrome for consumers. A homebuyer may see no advantage of paying a premium for a newer-code home (which may have fewer amenities) relative to an older home that has stood the test of several severe natural disasters. In other words, consumers have a greater preference for additional amenities as opposed to disaster mitigation. In addition, factors such as the cost-effectiveness of substituting hazard insurance for hurricane disaster, consumers’ preferences for product characteristics over solid construction, and the availability of social insurance (efficient evacuation, National Guard protection of property) may affect the value that consumers attach to the stricter building code.

Consumer behavior reverses, however, after the 2005 hurricanes. These storms had a much greater impact on south Florida. Following these disasters, the premium for the stricter building code returns and, for one area, is greater than it was previously.

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APPENDIX

TABLE 1. VARIABLE DEFINITIONS

Variable	Definition
Ln(sp)	Log of sale price ln(*sp*) = dependent variable
SqFt	The square footage of the house
Lotsize	Size of the lot
Age	The age of the house in years
Baths	The number of bathrooms
Swimming Pool	Binary variable with a value of one if the house has a swimming pool, zero otherwise
HhSize	Average household size by census block
HhIncome	Average household income by census block
Bldgcode	Binary variable with a value of one if the house was built under the stricter 1994 South Florida Building Code, zero otherwise
BldgcodePostH1	Binary variable with a value of one if the house was built under the stricter 1994 South Florida Code and was sold between October 2004 to June 2005 (after the last hurricane in 2004 and before the first hurricane of 2005), zero otherwise
BldgcodePostH2	Binary variable with a value of one if the house was built under the stricter 1994 South Florida Code and was sold between November 2005 to May 2006 (after last hurricane of 2005 to beginning of next hurricane season), zero otherwise
BldgcodePostH3	Binary variable with a value of one if the house was built under the stricter 1994 South Florida Code and was sold after December 2006 into 2007 (after the 2006 hurricane season), zero otherwise
Zone 1	Binary variable with a value of one if the house is within 1,500 feet from the coast, zero otherwise
Zone 2	Binary variable with a value of one if the house is between 1,500 feet and ten miles from the coast, zero otherwise
Zone 3	Binary variable with a value of one if the house is located more than ten miles from the coast, zero otherwise
Y2000 – Y2007	Time trend variables for the years 2000 through 2007
Fall	Binary variable if the house was sold during the fall season (September, October, and November), zero otherwise
Winter	Binary variable if the house was sold during the winter season (December, January, and February), zero otherwise
Spring	Binary variable if the house was sold during the spring season (March, April, and May), zero otherwise
Summer	Binary variable if the house was sold during the summer season (June, July, and August), zero otherwise

Table 2
Descriptive Statistics
Aggregate and Zone 1

	Panel A: Aggregate (N=57001)				Panel B: Zone 1 (N=1851)			
VARIABLE	**MEAN**	**MIN**	**MAX**	**StdDev**	**MEAN**	**MIN**	**MAX**	**StdDev**
Price	343754.4	50000	5000000	369329.5	1367996	55000	5000000	912589.9
SqFt	2282.680	826	9847	1019.109	4104.8	900	9652	1431.1
Lotsize	11064.540	1456	2182061	15945.440	12862.5	1747	89668	7684.4
Age	15.212	0	37	11.094	15.670	0	37	11.630
Baths	2.284	1	8	.802	3.754	1	8	1.403
Swimming Pool	.329	0	1	.470	.842	0	1	.365
Bldgcode	.350	0	1	.477	.361	0	1	.480
BldgcodePostH1	.038	0	1	.191	.053	0	1	.224
BldgcodePostH2	.024	0	1	.154	.019	0	1	.138
BldgcodePostH3	.019	0	1	.137	.019	0	1	.136
HhSize	3.296	1.43	4.92	.436	2.602	1.59	3.73	.587
HhIncome	61614.4	7222	200001	29178.3	117423.0	21030	200001	56875.8
Y2000	.131	0	1	.337	.141	0	1	.348
Y2001	.136	0	1	.342	.132	0	1	.339
Y2002	.137	0	1	.343	.127	0	1	.334
Y2003	.136	0	1	.343	.131	0	1	.338
Y2004	.151	0	1	.358	.172	0	1	.378
Y2005	.138	0	1	.344	.147	0	1	.355
Y2006	.112	0	1	.316	.089	0	1	.284
Y2007	.060	0	1	.238	.060	0	1	.237
Spring	.274	0	1	.446	.260	0	1	.439
Summer	.274	0	1	.446	.315	0	1	.465
Fall	.233	0	1	.422	.209	0	1	.407
Winter	.219	0	1	.414	.216	0	1	.412
Zone 1	.032	0	1	.177				
Zone 2	.705	0	1	.456				
Zone 3	.263	0	1	.440				

Table 2 Continued
Descriptive Statistics
Zone 2 and Zone 3

	Panel C: Zone 2 (N=40234)				Panel D: Zone 3 (N=15015)			
VARIABLE	**MEAN**	**MIN**	**MAX**	**StdDev**	**MEAN**	**MIN**	**MAX**	**StdDev**
Price	322790.6	50000	5000000	311491.8	273663.8	54000	3162000	143891.9
SqFt	2240.4	826	9847	1013.3	2171.3	828	9545	720.9
Lotsize	11243.9	1456	466446	10947.3	10362.2	2627	2182061	25249.9
Age	17.059	0	37	11.613	10.207	0	37	7.467
Baths	2.232	1	8	.781	2.239	1	8	.541
Swimming Pool	.346	0	1	.476	.222	0	1	.416
Bldgcode	.316	0	1	.465	.440	0	1	.496
BldgcodePostH1	.036	0	1	.186	.042	0	1	.200
BldgcodePostH2	.024	0	1	.154	.025	0	1	.156
BldgcodePostH3	.019	0	1	.135	.021	0	1	.142
HhSize	3.262	1.43	4.92	.449	3.473	2.36	4.01	.214
HhIncome	60148.6	7222	200001	29155.7	58662.5	27315	85422	12763.0
Y2000	.123	0	1	.329	.151	0	1	.358
Y2001	.130	0	1	.336	.151	0	1	.358
Y2002	.133	0	1	.339	.148	0	1	.355
Y2003	.138	0	1	.345	.132	0	1	.338
Y2004	.153	0	1	.360	.142	0	1	.349
Y2005	.140	0	1	.347	.130	0	1	.336
Y2006	.120	0	1	.325	.095	0	1	.294
Y2007	.063	0	1	.244	.052	0	1	.221
Spring	.273	0	1	.446	.277	0	1	.448
Summer	.277	0	1	.448	.261	0	1	.439
Fall	.232	0	1	.422	.236	0	1	.425
Winter	.217	0	1	.412	.226	0	1	.418

Table 3
Regression Model Output
Dependent Variable = ln(sp)

	Aggregate Coefficient (Std. Error)	**Zone 1** Coefficient (Std. Error)	**Zone 2** Coefficient (Std. Error)	**Zone 3** Coefficient (Std. Error)
Constant	**11.865980***	**11.780750***	**11.466700***	**11.137510***
	(.010597)	(.057313)	(.010604)	(.024607)
Sqft	**.000282***	**.000227***	**.000296***	**.000257***
	(.000002)	(.000011)	(.000002)	(.000003)
Lotsize	**.000001***	.000002	**.000001***	**.000001***
	(.000000)	(.000002)	(.000000)	(.000000)
Age_Resid	-.000259	-.002659	.000339	.000356
	(.000152)	(.001484)	(.000177)	(.000314)
Baths	**.071227***	**.103364***	**.063757***	**.027923***
	(.001922)	(.009827)	(.002366)	(.003270)
Swimming Pool	**.117606***	**.179931***	**.119205***	**.094899***
	(.002421)	(.027721)	(.002843)	(.003649)
Bldgcode	.003392	**.103620***	**.006618**	**.014185***
	(.002292)	(.024850)	(.002829)	(.003127)
BldgcodePostH1	**-.026467***	**-.104655**	**-.028902***	**-.015589**
	(.005553)	(.047476)	(.006807)	(.007554)
BldgcodePostH2	.010472	.025658	-.003592	**.035403***
	(.006706)	(.071518)	(.008025)	(.009420)
BldgcodePostH3	.015732	-.031332	.011098	.005332
	(.008179)	(.080946)	(.009803)	(.011650)
HhSize	**-.198681***	.031075	**-.204894***	**-.013799**
	(.002416)	(.021110)	(.002637)	(.006617)
HhIncome	**.000005***	**.000001***	**.000005***	**.000004***
	(.000000)	(.000000)	(.000000)	(.000000)
y2001	**.090954***	**.102677***	**.097327***	**.078546***
	(.003630)	(.035047)	(.004450)	(.004842)
y2002	**.222410***	**.164196***	**.232376***	**.203779***
	(.003624)	(.035370)	(.004428)	(.004869)
y2003	**.366953***	**.270291***	**.373942***	**.362416***
	(.003633)	(.035189)	(.004392)	(.005030)
y2004	**.542896***	**.420332***	**.546332***	**.548955***
	(.003580)	(.033231)	(.004322)	(.005006)
y2005	**.777161***	**.701579***	**.778198***	**.788361***
	(.003823)	(.036167)	(.004591)	(.005411)
y2006	**.926454***	**.739158***	**.929151***	**.957141***
	(.003962)	(.040267)	(.004699)	(.005794)
y2007	**.934658***	**.776818***	**.932047***	**.981837***
	(.005216)	(.050673)	(.006086)	(.008063)
spring	**-.009023***	.033591	**-.010178***	**-.014280***
	(.002686)	(.026626)	(.003219)	(.003771)
summer	**.022070***	**.052746**	**.018734***	**.023147***
	(.002711)	(.025737)	(.003239)	(.003859)
fall	**.050082***	**.059649**	**.046417***	**.056824***
	(.002798)	(.028099)	(.003351)	(.003929)
Zone 2	**-.379881***			
	(.005954)			
Zone 3	**-.283979***			
	(.006271)			
R2	.8823	.6772	.877	.8698
N	57100	1851	40234	15015

Bold text- Significant at the 5% level; *- Significant at the 1% level