INSURANCE & LIABILITY

DO COASTAL BUILDING CODES MAKE STRONGER HOUSES?

Houses built under FEMA guidelines suffer more damage than pre-guidelines houses.

BY CAROLYN A. DEHRING AND MARTIN HALEK

The National Flood Insurance Program (NFIP), which provides federal flood insurance to property owners in participating communities, is currently $24 billion in debt. The shortfall has long been foreseen by policymakers because the insurance is underpriced, effectively subsidizing property owners of coastal properties. Congress attempted to curtail that subsidy with the 2012 Biggert–Waters Flood Insurance Reform Act, which was intended to put the burden of flood risk squarely on property owners rather than taxpayers. However, beneficiaries of the subsidies rallied against the legislation, and earlier this year both houses of Congress passed, and President Obama signed, legislation delaying the 2012 subsidy reform.

Communities that participate in the NFIP must adopt the program's building code, which incorporates minimum building standards set forth by the Federal Emergency Management Agency (FEMA). Economists have theorized that building codes associated with the provision of subsidized insurance may create moral hazard by inducing risk taking. That is, the acquisition of insurance against some contingency is associated with a decreased incentive to avoid or prevent the insured loss because policyholders do not bear the full consequences of their actions. Independent of any insurance provision, moral hazard can also result from a false perception of safety if building codes are not effective.

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This article examines the effectiveness of the NFIP's building code in reducing damages to barrier island property in a hurricane. We determine whether similarly located properties fare better or worse in a hurricane based on the code regime under which they were constructed. We use data from Lee County, Fla., where 2004's Hurricane Charley made landfall. Our findings raise questions about the optimal scale of code design, and about unintended consequences from building code changes.

COASTAL BUILDING CODES

In this country, government limits the bundle of rights associated with real property ownership through building codes, also referred to as construction codes. The codes set standards for various aspects of construction, including fire prevention, structural integrity, and general health and safety. Unlike in Canada, where a national building code is used, local building codes in the United States may be based on a model code or a state code. Building codes are enforced by local governments as an exercise of police power. The two economic justifications for building codes are that homebuyers cannot accurately assess the structural integrity of a housing unit (information asymmetries) and that without codes the construction decisions of one person may endanger others (externalities).

Building construction in areas prone to flood hazard is often regulated at the federal or state level. In Florida, coastal setback lines, known as coastal construction control lines (CCCLs), designate areas having the potential for extreme fluctuation in the event of a "100-year storm"—that is, a storm so severe that its probability of occurring is only 1 percent in a given year. Special siting and design criteria apply to construction seaward of the CCCL. In addition, most Florida communities participate in the NFIP.

Southwest Florida's Lee County first adopted coastal construction codes in the mid-1970s. The codes established two or three zones on each of the county's barrier islands, which were delineated by distance from the shoreline. Building requirements were strictest in the seaward-most zone, which included those properties fronting the Gulf of Mexico. There, buildings had to be elevated above the National Geodetic Vertical Datum (NGVD) of 1929 (often referred to as mean sea level) and anchored to pile foundations. A pile is a column—typically made of wood, steel, or concrete—that is driven deep into the ground to provide support for a structure. The size of the piles, as well as their spacing, depth of embedment, and force-bearing capacity, were specified in the county code. The code also specified horizontal wave and uplift pressures. Finally, buildings were

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required to be elevated between 12 and 13.5 feet above the mean sea level, measured from the first finished floor or from the underside of the building in the seaward-most zone(s).

In the landward-most barrier island zones (which included properties on the eastern sides of the islands), columns on footings (pier foundations) were permitted as an alternative to pile foundations. The footing is the widened section at the base of a column (pier) on which a column rests. Enclosed rooms with non-load-bearing, breakaway walls were permitted under the first finished floor in more landward zones.

Lee County's coastal building codes changed when it joined the NFIP in 1984. Base Flood Elevations (BFEs)—the estimated floodwater level from a 100-year storm—were established throughout the county, above which new structures and substantial improvements to old structures must be raised. NFIP building standards also require that materials and construction methods minimize flood damage. The regulations further prohibit the location of any electrical or heating equipment below the BFE and, more generally, any human habitation below the BFE.

Under the NFIP, all inhabitable barrier island land in Lee County received either an "A-Zone" or "V-Zone" designation, both of which indicate a Special Flood Hazard Area. A-Zone land is subject to rising water from coastal flooding. Elevation requirements in the A-Zone stipulate that the top of the proposed lowest floor (including basements) must be elevated to or above the BFE. V-Zone (velocity) land is subject to storm wave action in addition to the rising water from coastal flooding. V-Zone elevation requirements warrant the lowest supporting horizontal member (the lowest beam or joist that supports the elevated building) to be located at or above the BFE level. In essence, for the same base flood elevation, V-Zone buildings will be higher by the difference between the underside of the building and the top of the lowest floor of the building, or 1–2 feet on average. In the V-Zone, all construction must be securely anchored on piles or columns, and designed and anchored to withstand all anticipated weight or force to be borne by the base flood. In the A-Zone, there are no requirements regarding the foundation system; piles, columns on footings, or monolithic slab foundations are all permissible in the A-Zone.

In 1991, Lee County underwent a reestablishment of the 1978 CCCL, generally shifting the line landward. Coastal setback lines were introduced in 1971 as part of the Beach and Shore Protection Act. Those lines, now referred to as CCCLs, apply to beach or dune areas having the potential for extreme fluctuation in the event of a 100-year storm. Construction in the area must adhere to special siting and design criteria, as structures must be able to withstand physical forces and waves from storms, water pressure from flooding, and the effect of soil loss from storm-induced erosion. Improvements on structures constructed partially or totally seaward of a CCCL must have the lowest horizontal structural beam located above the predicted breaking wave crest. Importantly, the CCCL elevation is engineered to incorporate additional risks such as scour, wind, and long-term beach erosion, whereas the BFE accounts for rainstorm and coastal flood risks. To develop in this area requires the builder to obtain a CCCL elevation certificate, prepared by or under the direct supervision of a registered land surveyor, professional engineer, or architect licensed by the State of Florida. Similarly, a permit is required to modify, repair, or rebuild a structure when the proposed changes involve changes to the structure's foundation.

The NFIP regulations may create a perception of safety or transfer responsibility away from the homeowner, which may lead to moral hazard by inducing risk taking behavior.

AN EMPIRICAL STUDY OF CODE EFFECTIVENESS

In this study, the effect of changes to coastal building codes on both the incidence of hurricane damage and the extent of that damage is revealed through an empirical model. In this framework, we explain the likelihood that a residential property was damaged in Hurricane Charley, and (conditional on damage) the percent of structural damage incurred. We explain the incidence or extent of damage based on the location of the structure, structural features such as house age, size, and price per square foot to proxy building quality, and finally the permit date. The permit date indicates whether construction occurred under the old county code or under the later code adopted with participation in the NFIP. It also reveals whether property was affected by the reestablishment of the county's CCCL.

The effect of the various code changes on property damage is a priori ambiguous. Consider the NFIP building regulations. It is reasonable to assume that the higher and more flood-proof the building is, the lower the risk of flood inundation. However, as discussed earlier, NFIP regulations may create a perception of safety or transfer responsibility away from the homeowner, which may lead to moral hazard by inducing risk taking behavior. For example, a household may use less expensive or inferior material in the construction of the property and may be less likely to protect its property in ways not explicitly mandated by regulations (e.g., taking last-minute precautions to shutter doors and windows). Also, elevation and flood-proofing are not costless and

consumers may substitute less expensive technologies or inferior workmanship where available to compensate for the increased costs of NFIP compliance. Finally, because county coastal construction codes were already in place prior to NFIP participation, any effect of code changes on damage must be interpreted relative to the existing code. Thus, the cumulative effect of NFIP code changes on property damage is best resolved empirically. Along the same lines, the effect of the CCCL reestablishment on damage is a priori ambiguous because of the existing county codes that were already in place.

Lee County was selected for the study for several reasons. First, it is the county where Hurricane Charley made landfall. Charley was the second major hurricane of the 2004 Atlantic hurricane season and the most powerful storm to strike Southwest Florida since 1960. The Category Four hurricane made landfall on Lee County's North Captiva Island, with maximum winds near 150 miles per hour. North Captiva Island was severed into two parts when the right eye-wall of Charley passed over the island. Today, Charley stands behind Hurricane Katrina in 2005 and Hurricane Andrew in 1992 as the third costliest hurricane in U.S. history, with property damage estimated by the National Hurricane Center at $15 billion.

Lee County was also selected for the study because of the availability of permit data and damage records. The county property records provide a building permit date for all structures built after 1980. Accurately controlling for the relevant building code regimes is of critical importance, as new building code requirements do not apply to structures for which a valid and unexpired building permit has been issued. Our sample includes only those properties for which building permits were granted after January 1, 1980 and for which we were able to verify a valid building permit date.

In terms of damage estimates, the county assessed structural damage to all barrier island land after Charley. Property damage estimates were assigned by the Lee County Property Appraiser's Office, whether the original source was a Lee County Emergency Operations Center damage report, a homeowner damage report, or a property appraiser's field inspection. The damage estimates were in some cases categorical (e.g., minor, major, etc.), and in some cases a percentage estimate of overall damage was provided. Our final sample includes percentage estimates derived from professional appraisers with the county. The Lee County Property Appraiser's Office also provided NFIP flood zone categorization and other structural attributes. Visual inspection of each property through the Lee County Property Appraiser website was used to determine distance from the Gulf of Mexico, whether the building site is seaward or landward of the 1991 CCCL, and what zone the property would have been in under the old county code. Our final sample includes 264 residential properties on Lee County's barrier islands. Of those, 233 properties incurred some damage.

MAJOR FINDINGS

We find the construction code in place at the time the property was built affects both the incidence of damage and the extent of damage. Specifically, structures built after the implementation of the NFIP code and located in the A-Zone are significantly more likely to sustain damage than similarly located structures built prior to NFIP regulation. Conditional on damage being sustained, post-NFIP construction in the A-Zone incurs almost 57 percent more total damages than similarly located property built under the old county code. We also find that properties seaward of the 1991 CCCL and built following the line's reestablishment incur 47.5 percent more total damage than similarly located residences built prior to the reestablishment.

TABLE 1

CHANGE IN MINIMUM REQUIRED ELEVATION (in feet)

Post-NFIP vs. Pre-NFIP

Elevation change (feet)	Full Sample	*A-Zone*				*V-Zone*			
		All	Pre-NFIP	Post-NFIP	Post-damaged	All	Pre-NFIP	Post-NFIP	Post-damaged
–4	1	1	0	1	1	0	0	0	0
–3	18	18	1	17	16	0	0	0	0
–2	20	19	2	17	15	1	0	1	1
–1	32	25	2	23	22	7	0	7	6
Total reductions	71	63	5	58	54	8	0	8	7
0	112	25	3	22	21	87	13	74	67
1	8	1	0	1	1	7	1	6	6
4	1	1	1	0	0	0	0	0	0
12	4	4	2	2	1	0	0	0	0
13	2	2	1	1	1	0	0	0	0
14	2	2	1	1	0	0	0	0	0
Total increases	17	10	5	5	3	7	1	6	6
Total	**200**	**98**	**13**	**85**	**78**	**102**	**14**	**88**	**80**

NOTES: "A-Zone" = areas subject to rising flood waters. "V-Zone" = areas subject to both a storm surge and rising waters. Observations = 200. The 64 Sanibel Island properties are not included.

While consistent with the alternative hypothesis of building codes discussed earlier, our results are troubling given that both programs are designed to protect structures against damage from flood and storm events. However, any conjectures regarding the cause of our results is not satisfying without further empirical support.

To better explain our results, at least with regard to the NFIP A-Zone, we compare the specific code requirements under the NFIP against the previous code regime for each individual property. Because we could not obtain pre-NFIP building code data for Lee County's Sanibel Island, the island's property is not included in the analysis

First, we compare building elevation requirements under the old county code to those under NFIP regulation. Changes in required elevations by code regime, flood zone, and damage frequency are presented in Table 1. For the full sample, we see that 71 properties had a *reduction* in minimum required elevation of between 1 and 4 feet when the county joined the NFIP. Of those properties, 63 were in the A-Zone and eight were in the V-Zone. Of the rest of the sample, 112 properties had no change in elevation and 17 had increases in elevation. Analysis of the damaged post-NFIP sample indicates a 1-foot decrease in elevation increases damage by 1.267 percent.

Next, we look at damaged A-Zone properties to see whether those that would have been required to have pile foundations under the old code (Zone 1 and 2) sustained more damage than those that would have been allowed weaker foundations under the old code (Zone 3). As can be seen in Table 2, most of the A-Zone properties would have been classified as Zone 3 under the old code regime. However, 21 properties designated as A-Zone would have been classified as Zone 1 or 2 under the old code. Both the mean and median damage is higher for the A-Zone properties that would have been in the stricter Zones 1 and 2 under the old code. Statistically, relative to all post-NFIP A-Zone construction, those properties that would have received a Zone 1 or 2 designation under the old code are associated with increased damage on the order of 8 percent.

Finally, to further explore what is driving our A-Zone results, we explain damage to various building components, including roof, exterior wall of the structure, interior wall of the structure, and floor system, respectively. We expect damage to the floor and the interior wall in a flood or storm surge to be related to elevation or building foundation, while roof and exterior wall damage should be associated more with wind damage. We find some evidence of a higher likelihood of roof damage or exterior wall damage for those A-Zone properties built after NFIP implementation relative to similarly located pre-NFIP construction. However, we find stronger evidence that the likelihood of interior wall damage and floor damage are higher for those A-Zone properties built post-NFIP.

Table 2

DAMAGE FREQUENCY FOR POST-NFIP CONSTRUCTION IN THE A-ZONE

	A-Zone damage	Mean damage	Median damage
Zone 1 or 2	21	26.1%	26.5%
Zone 3	57	18.3%	12.5%
Total	**78**		

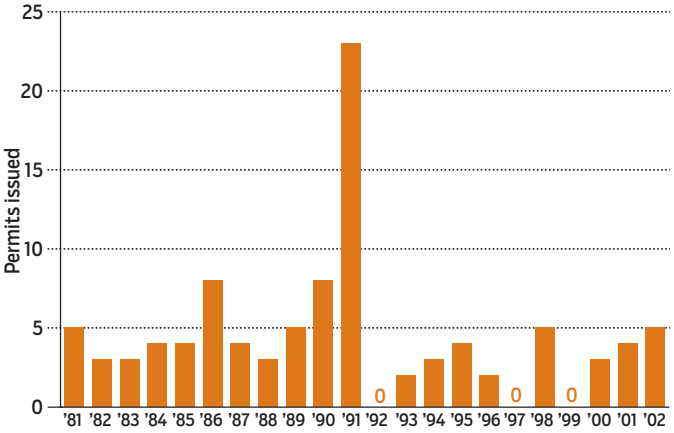
NOTES: "A-Zone" = areas subject to rising flood waters.
Observations = 78.

Because of the nature of the siting and design requirements for properties seaward of the CCCL, we cannot further explore the causes of our findings with regard to the 1991 CCCL reestablishment. However, an analysis of building permits over time tells an interesting story. Figure 1 shows the number of permits by year for properties seaward of the 1991 CCCL, and Figure 2 shows the number of permits by year for properties landward of the line. A run on permits for properties seaward of the 1991 CCCL right before its

Figure 1

LEE COUNTY BUILDING PERMITS BY DATE

All properties seaward of 1991 CCCL

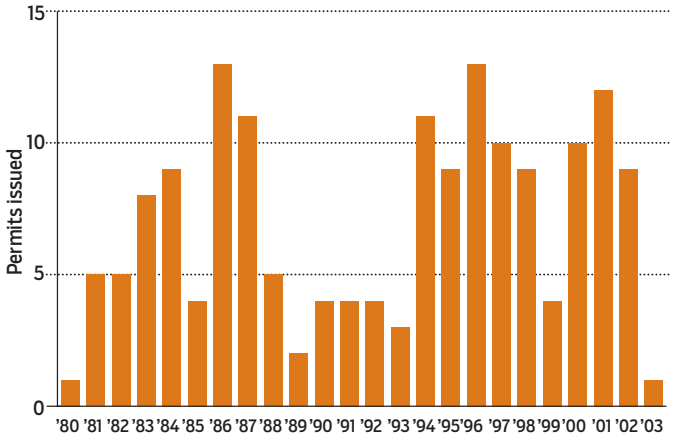


Note: N = 98.

Figure 2

LEE COUNTY BUILDING PERMITS BY DATE

All properties landward of 1991 CCCL



Note: N = 166.

establishment suggests market participants viewed the regulations as having consequence. Indeed, in 1991, all 23 permits for property seaward of the line were issued before the May 30, 1991 effective date of the CCCL. Thus, the CCCL reestablishment appears to have spurred preemptive development—an outcome that runs counter to the goal of the very regulations that established the CCCL.

CONCLUSION

In Florida alone, over $3.7 billion in losses have been paid through the NFIP since 1978. Florida leads the nation with just over 2 million NFIP policies in force—an amount over three times that of Texas. Losses from future hurricanes will likely increase as coastal populations continue to grow. One estimate of residential and commercial coastal property exposures in Florida stands at $1.94 trillion; that number will certainly increase as development continues. Hence, the ex ante mitigation of losses to coastal properties from natural disasters has become a vital concern. Moreover, the economic significance of any proposed effective loss control device prior to implementation is of great importance.

Our study investigates whether state and federal mandated changes in coastal building standards mitigate hurricane damage to residential properties in high-hazard coastal areas. We find that coastal construction code changes associated with the NFIP are associated with more structural damage to coastal property. Specifically, after controlling for locational and physical attributes of the structure, we find coastal zone properties located in an NFIP A-Zone that were built in compliance with FEMA requirements have an increased likelihood of property damage—and a greater extent of property damage conditional on some damage being sustained—relative to similarly located pre-NFIP-built structures. A comparison of the building requirements under the NFIP relative to what was in place at the county level before the NFIP provisions reveals that most A-Zone land in the sample was actually subject to a "decrease" in coastal building standards in terms of both lower required elevation and less stringent foundation requirements. Additional analysis on structural component damage in the A-Zone reveals a higher incidence of floor and interior wall damage, consistent with flood damage.

The empirical findings concerning overall structural damage are consistent with the literature in terms of land prices and coastal construction code changes. In a 2006 *Land Economics* paper, Carolyn Dehring examines the effect of those same coastal code changes on vacant land prices on Lee County's barrier islands. Land prices are found to decrease by as much as 30 percent following code changes associated with the NFIP and the CCCL reestablishment. Our current study implies that market participants may have indeed priced the effect of the code changes accurately.

Our findings raise questions concerning the optimal scale of code design and enforcement. There has been a shift in recent decades away from local codes to state or model codes. Currently, 41 states mandate a model code or state code, compared to 15 in 1976. While model codes introduce efficiencies in design, they may be subject to political interference by manufacturers and trade associations. Further, the codes may be based purely on visible factors, possibly at the sacrifice of overall construction quality. On the other hand, our findings may suggest that the NFIP's A-Zone standards are not well suited for barrier islands.

It may be that there were code enforcement issues associated with damage from Hurricane Charley. Indeed, code enforcement was a factor in Hurricanes Andrew and Charley in neighboring Charlotte County where claims payments (and hence implied damages) were less for properties built after 1992. However, in the current study we do not find less incidence of damage, or extent of damage, for homes built after 1992, when Florida revisited its building code.

We find coastal zone properties located in an NFIP A-Zone that were built in compliance with FEMA requirements have an increased likelihood of property damage relative to similarly located pre-NFIP-built structures.

As the viability of the NFIP is debated in the coming years, both insurance rates and code effectiveness deserve scrutiny. An inability to access comprehensive and accurate data has restricted opportunities for further research on the effectiveness of regulation in mitigating structural risk to property in high-hazard areas. If such data were made available (e.g., NFIP participation by parcel), that would facilitate a more accurate assessment of moral hazard in this context. Cooperation from FEMA, insurance companies, professional appraisers, coastal engineers, and social scientists would improve both the quantity and quality of research in this critical area. Our investigation is but one instance where empirical evidence suggests that regulation modifications produce unintended effects in terms of structural damages caused by hurricanes. *R*

READINGS

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