Hurricanes, Housing Market Activity, and Coastal Real Estate Values

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abstract

Assuming hurricane landfalls are random events for a given coastal community, a single storm or even a pair of storms should have no appreciable effects on property values. However, we hold that the increased frequency of strikes in our study area does not favor housing prices. We believe that housing market participants in that region may no longer view the landfalls as random, and consequently, home prices may fall. We have developed a standard hedonic pricing model that permits us to examine real estate values following these natural disasters.

Rational home buyers or sellers recognize the possibility of bad luck and usually make no adjustment in their home-buying willingness or pricing expectations as a result of one or two hurricane strikes. However, we hold that an increased frequency of strikes in an area does not favor housing prices. With successive hurricanes over a relatively brief period, we believe that housing market participants may no longer view the landfalls as random, and consequently, home prices may fall. We have developed a standard hedonic pricing model that permits us to examine real estate values following these natural disasters. After controlling for local economic and housing activity and costs of home financing—factors often influencing housing prices—we find little separable response by the market to initial hurricane strikes. However, we observe adverse, progressively greater impacts on home selling prices in the months following successive hurricanes.

The human and material costs of catastrophic events such as floods, earthquakes, and hurricanes invite broad review in the daily, financial, academic, and insurance press. Reports give an inventory of the personal and financial impacts of these events. The public calls for greater government involvement in the prediction of natural disasters and for stronger measures to minimize losses when these catastrophes occur.

We haven't found a study, however, that considers the impact on home values of increasing expectations of hurricane strikes. This is despite migratory and development patterns within the United States that amplify the potential costs of these events, independent of changing hurricane probabilities. The ultimate losses due to hurricane strikes along the Atlantic coast, for example, are greater today than ever. Hurricanes cause billions of dollars in immediate observable property damage. Hurricane Hugo inflicted close to $8 billion in damage in South Carolina in 1989. Hurricane Andrew left over $28 billion in prop-

Acknowledgement: This research was funded in part by grants from the Center for Applied Real Estate Education and Research, University of South Carolina, and the Charles L. Cahill Faculty Research and Development Award Program, University of North Carolina at Wilmington.

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erty damage in South Florida in 1992, destroying 64,000 homes, while Hurricane Floyd caused $5.45 billion in damage in eastern North Carolina in 1999.[1]

After accounting for changes in purchasing power, population, and wealth, Pielke and Landsea found that the average annual U.S. hurricane damage from 1924 to 1997 was $5.2 billion; they also note that increasing coastal development exacerbates potential damage.[2,3]

We believe that there is an additional indirect cost that is not immediately observable; residential property values may suffer in an area at perceived elevated hurricane risk. To test this premise, we studied the relationship between hurricane strikes and residential property values in the coastal area of southeastern North Carolina where four hurricanes have recently made landfall: Hurricanes Bertha and Fran struck the area late in the summer of 1996, Hurricane Bonnie made landfall in August 1998, and Hurricane Floyd hit in September 1999.[4]

Literature and Theoretical Basis

Potential losses for insurers and property owners and the appropriateness of certain government responses frame recent empirical and theoretical examinations of hurricane losses. Studies consider the costs and predictability of hurricanes[5] or examine the exposure of the insured and the insurer.[6] Authors also review the suitable roles of real estate owners, lenders, and the government in mitigating the damages caused by hurricanes.[7]

These varied stakeholders, from insurers to property owners to local and federal governments, have distinct interests, from assuring the viability of their businesses for the insurers to protecting against substantial and unforeseen damages for the real estate owners. Research is broadly conducted toward a better understanding of the responses by the varied parties to the continuing risk of hurricane landfalls, and to the greater damages that result with increasing population concentrations along the Atlantic coast.

Several authors find links between natural disasters and residential or commercial property values.[8] Pedrozo reports a "small significant [residen-

1. B. Pisani, "Lessons from Hurricane Andrew," *The Real Estate Finance Journal* (9: 1, 1993): 44; P. Hebert, J. Jarrell, and M. Mayfield, "The Deadliest, Costliest and Most Intense United States Hurricanes of This Century (and Other Frequently Requested Hurricane Facts)," National Oceanic & Atmosphere Administration, Technical Memorandum NWS TPC-1 (Miami: National Hurricane Center, 1997); North Carolina Office of the Governor, "Governor Hunt Calls Special Session for Flood Relief," press release (Raleigh, N.C.: December 8, 1999).
2. R. A. Pielke Jr. and C. W. Landsea, "Normalized Atlantic Hurricane Damage, 1925–1995," *Weather Forecasting* (13, 1998): 621–631.
3. R. A. Pielke Jr. and C. W. Landsea, "La Nina, El Nino and Atlantic Hurricane Damages in the United States," *Bulletin of the American Meteorological Society* (October 1999).
4. Substantial coastal development and the popularity of oceanfront communities highlight the currency of this research topic. Not surprisingly, increasing hurricane damage as a result of ever-increasing oceanfront development invites extensive review in the local media.
5. R. A. Pielke Jr. and C. W. Landsea, "La Nina, El Nino and Atlantic Hurricane Damages in the United States," *Bulletin of the American Meteorological Society* (October 1999); P. Herbert, et al., Ibid.
6. G. Chichilnisky and G. Heal, "Managing Unknown Risks," *Journal of Portfolio Management* (24: 4, 1998): 85–91; L. A. Angbazo and R. Narayanan, "Catastrophic Shocks in the Property-Liability Insurance Industry: Evidence on Regulatory and Contagion Effects," *Journal of Risk and Insurance* (63: 4, 1996): 619–637; D. J. Meyer and J. Meyer, "The Comparative Statics of Deductible Insurance and Insurable Assets," *Journal of Risk and Insurance* (66: 1, 1999): 1–15; and R. T. Kozlowski and S. B. Mathewson, "A Primer on Catastrophe Modeling," *Journal of Insurance Regulation* (15: 2, 1997): 322–341.
7. D. Dezube, "Living in a Disaster Area," *Mortgage Banking* (54: 9, 1994): 28–35; S. Brostoff, "Why Put the Feds in the Homeowners Insurance Market?" *National Underwriter* (99: 26, 1995): 18; M. H. Adams, "Florida Debates Solutions to Storm Crisis," *National Underwriter* (99: 42, 1995): 4; M. H. Adams, "Florida Seeks Property Market Reforms," (101: 13, 1997): 4.
8. Many researchers report the effect of factors other than hurricanes on home selling prices. In addition to general economic conditions, externalities having a positive impact on residential property values include a developer's "good will" (Chau, Ng, and Hung, 2001) and the property's proximity to a golf course (Do and Grudnitski, 1995), the ocean (Rush and Bruggink, 2000), or a nearby resort (Spahr and Sunderman, 1999). Positive effects are noted also for such factors as new residential construction nearby (Simons, Quercia, and Maric, 1998), "mature" trees on the property (Dombrow, Rodriguez, and Sirmans, 2000), condominium age restrictions (Allen, 1997), and expectations of local urban development (Isakson, 1997 and Guntermann, 1997). Negative impacts are noted for nearby underground storage tanks (Simons, Bowen, and Sementelli, 1997), proximate nuclear power plants (Gamble and Downing, 1982), and airport noise (Nelson, 1980). An adverse effect is reported also for high crime areas (Buck, Deutsch, and Hakim, 1991), "undesirable" traffic within a neighborhood (Nelson, 1980), air pollution (Nelson, 1978), and proximity to a landfill (Mohanty, Reichert, and Small, 1992).

tial price] change for one month only" following the 1994 Northridge earthquake in Los Angeles.[9] Brunette considers the 1989 Loma Prieta earthquake in San Francisco, Hurricane Andrew in 1992 in South Florida, and the Northridge earthquake.[10] He finds no significant reduction in commercial property returns in either San Francisco or Miami as a result of their natural disasters and is indeterminate on the effects of the 1994 Los Angeles earthquake. Murdoch, Singh, and Thayer also examine the impact of the Loma Prieta earthquake. They consider declining prices following the event, but after controlling for a set of descriptive variables, the authors find the earthquake had only a marginal impact—around 2%—on housing prices.[11] MacDonald, Murdoch, and White study the impact of the expectation of costly flooding in Monroe, Louisiana. The flooding expectations elicit 2.8% to 2.9% reductions in home values; these reductions are equivalent to the present value of increased insurance costs borne by homeowners at flood risk.[12]

Data Collection and Summary Statistics

Real estate market activities and the behavior of real estate market participants do not lend themselves easily to traditional financial or economic theory. The capital markets are more easily examined given their rich historical databases upon which to build research. The real estate market is much less structured; it includes a limited number of buyers and sellers. They deal with dissimilar products in a highly regulated market noted for its high transaction costs and abbreviated flows of information. Real estate products are relatively illiquid, and the ability of real estate prices to reflect quickly or fully relevant market factors is reduced relative to "typical" capital markets. However, a hedonic pricing model, suggested by Rosen, can be used to discover relationships between successive hurricane strikes and the selling prices of single-family homes in the region.[13]

To test our premise, we gather home selling data for the Wilmington, North Carolina market, an area of perceived increasing hurricane risk. We examine monthly housing sales between December 1995 and June 2000 for the contiguous New Hanover, Brunswick, and Pender Counties in southeastern North Carolina. Wilmington is the largest city in the area. In Figure 1, the "Area of Hurricane Strikes" near Wilmington specifies the region studied. Wilmington is effectively in the center of the three-county region. Data on single-family housing prices is obtained from the Multiple Listing Service (MLS) and the Association of Realtors in Wilmington. A set of descriptive statistics drawn from the data is given in Table 1.[14]

Data demonstrated in Table 1 is on units sold and average sales prices for each of nine sales areas between December 1995 and the second quarter of 2000. Home prices in Wrightsville Beach have averaged over $500,000 for much of the time since 1997; average prices in all the other regions are much lower, but unit sales in most other areas are higher. Unit sales in the northeastern, southeastern, and southwestern sections of New Hanover County dominate sales in other areas. A cursory review of Table 1 reveals flat or modestly increasing prices in most areas, with marked increases in prices in southwestern New Hanover County and in Brunswick County. In most areas, a fairly dramatic increase in prices is observed between 1997 and 1998, followed by a decline.

Figure 1 Area of Hurricane Strikes

9. N. Pedrozo, "Essays on Market Efficiency in Real Estate, Dissertation Abstract," *Journal of Real Estate Literature* (6: 1, 1998): 59.
10. D. Brunette, "Natural Disasters and Commercial Real Estate Returns," *Real Estate Finance* (11: 4, 1995): 67–71.
11. J. Murdoch, H. Singh, and M. Thayer, "The Impact of Natural Hazards on Housing Values: The Loma Prieta Earthquake," *AREUEA Journal* (21: 2, 1993): 167–184.
12. D. N. MacDonald, J. C. Murdoch, and H. L. White, "Uncertain Hazards, Insurance and Consumer Choice: Evidence," *Land Economics* (63: 4, 1987): 361–371.
13. S. Rosen, "Hedonic Prices and Implicit Markets," *Journal of Political Economy* (82, 1974): 34–55.
14. A complete set of descriptive data is available from the authors on request.

Table 1 Housing Sales in the Study Region for December 1995 and Subsequent Years' Selected Calendar Quarters

	Dec 1995		2Q 1996		2Q 1997		2Q 1998		2Q 1999		2Q 2000	
	Units Sold	Average Sales Price	Units Sold	Average Sales Price	Units Sold	Average Sales Price	Units Sold	Average Sales Price	Units Sold	Average Sales Price	Units Sold	Average Sales Price
New Hanover County												
Northeast	39	$175,536	133	$146,804	168	$171,467	216	$181,363	289	$169,160	77	$172,256
Southeast	39	$149,389	137	$153,744	185	$186,411	258	$176,935	231	$184,817	60	$165,249
Southwest	62	$97,648	142	$122,924	248	$121,402	281	$129,563	262	$132,664	84	$143,807
Northwest	27	$108,864	66	$74,575	83	$106,329	101	$106,362	89	$107,748	27	$107,339
Wrightsville Beach	6	$295,050	15	$341,172	19	$516,754	22	$617,430	40	$542,386	8	$262,563
Pleasure Island	12	$71,167	72	$99,914	72	$115,379	96	$120,312	99	$143,654	36	$143,018
Other Counties												
Coastal Pender County	10	$148,960	25	$145,275	29	$122,352	29	$158,095	41	$143,574	17	$174,088
Pender County	3	$157,992	12	$99,517	25	$74,919	16	$115,331	23	$89,979	24	$90,480
Brunswick County	2	$79,950	21	$129,619	25	$117,272	56	$189,258	51	$180,050	15	$170,277

Model Development

We employ the following model to reveal general pricing patterns in the study region over the period examined. We then control for hurricane landfalls and general economic factors that may also influence housing market activity.

Model 1.

$$\begin{aligned}\text{Ln (Real Sales Price)} = \ & \beta_0 + \beta_1 \text{ Time} \\ & + \beta_2 \text{ Time Squared} \\ & + \beta_3 \text{ NENHC} \\ & + \beta_4 \text{ SENHC} \\ & + \beta_5 \text{ SWNHC} \\ & + \beta_6 \text{ NWNHC} \\ & + \beta_7 \text{ WRBCH} \\ & + \beta_8 \text{ PLEAISL} \\ & + \beta_9 \text{ PENCOAST} \\ & + \beta_{10} \text{ PEN} + \varepsilon\end{aligned}$$

where:

Ln = the natural logarithm,
Time = a counter variable (0,…,54) for the months of the study,
Time Squared = the square of the time variable,
NENHC = Northeast New Hanover County,
SENHC = Southeast New Hanover County,
SWNHC = Southwest New Hanover County,
NWNHC = Northwest New Hanover County,
WRBCH = Wrightsville Beach,
PLEAISL = Pleasure Island,
PENCOAST = Coastal Pender County, and
PEN = the rest of Pender County.

Home prices are log-normally distributed, with real sales prices averaging around $175,000 (a natural log of 12.0725) near the end of the study period, with a maximum sales price of over a dozen times the average.[15] The log of the selling price adjusted for inflation (Real Sales Price) is the dependent variable in our examinations. To capture the effect of *general* pricing patterns over time, a monthly Time variable is employed in this first model. Given observed overall increases in value over the examination period, we expect a positive sign for this factor. Time Squared is used to portray any general pattern imbedded in the data of increasing or decreasing rates of pricing change. If home prices are increasing at a decreasing rate, we expect this factor to be negative. If, such as in the months following recent hurricanes, increasing prices reverse or slow their advance, this variable will capture that effect.

Location dummy variables are included to illustrate the separable impact of home locations, within the study area, on housing prices. Data for Brunswick County (Table 1) is held out as a control for the other locations. A positive and highly significant effect is anticipated for the Wrightsville Beach category, with signs and significances of other areas depending on their valuations relative to the averages for Brunswick County. Properties near the coast are generally more valuable than non-coastal areas. Pender County and Northwestern New Hanover County are expected to have the lowest location coefficients, as valuations in those areas are the lowest in the study region.

The expectations of the signs of the location coefficients are drawn from Table 1 and anecdotal knowledge of the study region. Results in Model 1 suggest that home prices are increasing over time, captured by the Time factor, but are also increasing at a slower rate (or decreasing), as illustrated by the sign of the Time Squared variable. The location of the home within the study region, portrayed by coefficients β_3 through β_{10}, is also key in describing home prices in this first model.

With this background of general pricing patterns in the area, we extend earlier studies with a suggestion that house prices may be further described by the date of a home's sale relative to the landfalls of a series of

Model 1. Results

Independent Variable	Predicted Sign	Coefficient	Significance Level (σ)
Intercept	+	11.07279	<0.0001
Time	+	0.00981	0.0010
Time Squared	–	-0.00015	0.0069
NENHC	+	0.37003	<0.0001
SENHC	+	0.41296	<0.0001
SWNHC	–	0.05725	0.2121
NWNHC	–	-0.12517	0.0068
WRBCH	+	1.32172	<0.0001
PLEAISL	+	0.04216	0.3579
PENCOAST	+	0.21305	<0.0001
PEN	–	-0.26785	<0.0001

15. The natural log of $1 million is 13.8155, illustrating the "smoothing" effect of using natural logs, versus actual sales prices, in our examinations.

hurricane strikes. In more detailed specifications below, we hold that home values, as proxied by MLS reported sales, are a function of the property's location, the sales timing during the period of study, and selected economic factors; these factors include local economic trends, housing sales activity, and the costs of home financing. After controlling for these general economic factors, we examine the home sales data before, during, and after the series of hurricane strikes.

In Model 2, the log of Real Retail Sales in the study area is included to capture the impact of the region's economy on the housing market. If changes in home values can be attributed to local economic conditions, this factor will control for that relationship; a direct relationship is anticipated between this variable and home prices, with these prices moving up or down with an improving or declining local economy. Turn is the turnover of the local available housing inventory; it is the ratio of the most recent monthly home sales in units relative to the available listed supply. This factor proxies for the general health of the local real estate market. The Real Home Mortgage Interest Rate_{t-2} is an interest rate with a two-month lag reflecting home financing costs; it is a 30-year fixed rate provided monthly by the Federal Reserve. The two-month lag is intuitively appealing as the time from a buyer's home-purchase decision (at which point interest rates have an influence) until the sale is reported by the MLS (typically around two months). This specification also provides a better statistical fit.

We employ three interactive factors to discover the relationship between local hurricane landfalls and housing prices. Fran is a dummy variable for the months following Hurricane Fran in late August 1996 until the landfall of Bonnie in August 1998. Bonnie captures the 11-month period following Hurricane Bonnie in August of 1998. Floyd describes housing prices during the 8-month period following the landfall of Hurricane Floyd in September 1999. The individual hurricane variables are used to separate the association between the periods following these storms and property values. An attempt is being made with these variables to discover whether the periods following the most recent hurricanes are associated with changing home values. No conclusion is offered as to whether or not the storms caused any change in values.

We do not expect the Fran variable to be significant, as the rational homebuyer is expected to consider the landfall of Hurricane Fran (and Hurricane Bertha a few weeks earlier) a random event. We expect the Bonnie and Floyd factors, however, to be associated with successively more adverse impacts on home prices.

Model 2.

$$\begin{aligned}\text{Ln (Real Sales Price)} = {} & \beta_0 + \beta_1 \text{ Time} \\ & + \beta_2 \text{ Ln (Real Retail Sales)} \\ & + \beta_3 \text{ Turn} \\ & + \beta_4 \text{ (Real Home Mortgage Interest Rate}_{t-2}) \\ & + \beta_5 \text{ Fran} \\ & + \beta_6 \text{ Bonnie} \\ & + \beta_7 \text{ Floyd} \\ & + \beta_8 \text{ NEHNC} \\ & + \beta_9 \text{ SENHC} \\ & + \beta_{10} \text{ SWNHC} \\ & + \beta_{11} \text{ NWNHC} \\ & + \beta_{12} \text{ WRBCH} \\ & + \beta_{13} \text{ PLEAISL} \\ & + \beta_{14} \text{ PENCOAST} \\ & + \beta_{15} \text{ PEN} + \varepsilon\end{aligned}$$

where:

Fran, Bonnie, and Floyd = the products of the dummy variables for the periods after each storm and time squared, respectively.

Model 2. Results

Independent Variable	Predicted Sign	Coefficient	Significance Level (σ)
Intercept	+	12.6716	<0.0001
Time	+	0.0058	0.0073
Ln (real retail sales)	+	-0.0814	0.5851
Turn	–	0.0476	0.8974
Real home mortgage interest rate_{t-2}	–	-0.9261	0.8298
Fran	–	-0.00001	0.9519
Bonnie	–	-0.00005	0.0990
Floyd	–	-0.00006	0.0720
NENHC	+	0.3624	<0.0001
SENHC	+	0.4172	<0.0001
SWNHC	–	0.0633	0.2148
NWNHC	–	-0.1261	0.0148
WRBCH	+	1.3366	<0.0001
PLEAISL	+	0.0578	0.2237
PENCOAST	+	0.2152	<0.0001
PEN	–	-0.2610	<0.0001

Coupling the influence of changing pricing patterns near the end of the study period with the most recent hurricane strikes provides additional insights. The sizes, signs, and significances of the hurricane factors are consistent with our main premises. No significant price change is observed after Hurricane Fran; its arrival was likely considered random by homebuyers and sellers. This lack of statistical power was evident even in unreported modelings of the immediate period six to 12 months after Fran. However, the negative signs and significances of the later hurricanes' factors imply that there is some noteworthy association between the arrival of Hurricanes Bonnie and Floyd and subsequent property values in the Wilmington area. The more negative value of the Floyd factor further implies, at a minimum, that the advance of property values slowed dramatically following Hurricane Floyd, having been abbreviated following Hurricane Bonnie.

From this model, three main conclusions can be reached. First, the largest portion of the home's value is described by the model's intercept and the property's location; marginal contributions to property values are made by a host of other factors. Second, the region is characterized over the study period by progressively higher home values, with the progression being abbreviated or reversed, on average, in the months following recent hurricane landfalls. The Floyd coefficient value, for example, suggests that average home values are over $10,000 less than they would have been absent the decrease in average home prices associated with Hurricane Floyd at the end of the study period.

This abbreviation of the progression in home values can be contrasted to the hurricane probabilities in Table 2. Data in Table 2, drawn from Burrus, Dumas, and Graham, suggests the actual expected annual losses to homeowners from hurricane strikes are likely very small.[16,17] Though losses nationally may be precipitous, losses in a given area are generally low. These losses are the product of a hurricane's probability and its associated damages to the home. In other words, if a Category 4 storm is expected to cause $40,000 damage to a "typical" home and its probability is .00254, then annual expected material losses from Category 4 storms become only $101.60, even in an area that is at perceived elevated hurricane risk.

The annual hurricane probabilities in Table 2 can be further used to calculate the likelihood of the four hurricane landfalls in the Wilmington area between 1996 and 1999. Assuming the hurricanes are independent events, the probability of successive hurricane strikes is the product of their individual probabilities each year. Table 2 shows that the implied probability over four years of four storms of Category 1 strength or greater is less than one in 10,000. Given the observed abbreviation in housing values, however, the real estate market is likely to be presupposing a set of much higher hurricane probabilities, provided that those hurricane risks are driving our results.

Finally, economic factors are insignificant in the selected models in describing property values; this is surprising, given expectations of the correlations between the real estate market, housing prices, and the local economy. In fact, alternative model specifications did not improve the variable significances or model specification. However, interest rates were at historically low levels during the entire study period, and accordingly, interest rate changes might be expected to have little impact on home prices. Moreover, given the possibility of dramatically rising inventories in both growing and contracting real estate markets, the turnover variable standing alone may not be significant.

Table 2 Tropical Weather Wind Speed Categories and Associated Probabilities for the Wilmington, North Carolina Area

Saffir-Simpson Storm Category	Category Wind Speed Ranges	Annual Probabilities of Maximum Sustained Winds
Tropical storm	39–73 mph	0.15336
Category 1	74–95 mph	0.02826
Category 2	96–110 mph	0.00817
Category 3	111–130 mph	0.00520
Category 4	131–154 mph	0.00254
Category 5	155+ mph	0.00010

16. R. Burrus, C. Dumas, and J. E. Graham, "Hurricane Storm Surge: Cost-Effective Mitigation in Wilmington, North Carolina," *Facing Our Future: Hurricane Floyd and Recovery in the Coastal Plain.* East Carolina University and Coastal Carolina Press (2001) and R. Burrus, C. Dumas, and J. E. Graham, "The Cost of Coastal Storm Surge Damage Reduction." *Cost Engineering* (43: 3, 2001b): 38–44.

17. An analysis of expected hurricane losses to homeowners in the region is given in Burrus, et al. Probabilities in Table 2 are provided by the National Weather Service.

Inasmuch as local retail sales have been growing steadily over the study period, their influence is likely reflected in the time variable. This does not suggest that these general economic factors are unimportant to the real estate market; it merely indicates that other included variables like location, time, and the interactive hurricane dummy variables are far more important.

Conclusion

A retrenchment in reported home selling prices is observed in the Wilmington area in the months following Hurricanes Bonnie and Floyd in 1998 and 1999, respectively. Some of the effects at the end of the study period might have been expected in an area that had witnessed rapid growth over a number of years. However, the adverse impact following Bonnie in 1998, in an otherwise healthy economy, is an exception; coupling the patterns of falling home values after both Hurricanes Bonnie and Floyd (and not following earlier storms) suggests that the housing market may be responding to a new set of variables. While attributing the entire effect following Hurricane Floyd to the hurricane is tenuous, it seems likely that the fourth of a series of hurricanes in the area over a three-year period adversely affected home values.

Thus, observed weakness in the home market can, in part, be explained by the last two hurricane strikes. No similar declination is noted following earlier hurricanes; those are more easily considered random and not part of a pattern of increased susceptibility to hurricane strikes. A change has not necessarily occurred in the probability of a hurricane landfall in the study region, but the appearance of an increase in the probability of costly hurricane strikes may have contributed to the reported changes in housing prices.

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