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INSURANCE AND SOCIETAL VULNERABILITY TO HURRICANES

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Abstract

Katrina demonstrated the growing vulnerability of the United States to major hurricanes. This paper analyzes the sources of growing hurricane vulnerability, or increasing numbers of persons and real property in coastal counties in U.S. Atlantic and Gulf counties since 1950. The analysis specifically focuses on policy interventions in insurance markets, or states with "hurricane pool" residual market mechanisms. Regressions show that coastal county growth increased after establishment of a pool by 16,000 to 22,000 persons and 4,000 to 6,000 housing units per decade. But hurricane pools do not affect the percentage growth rates of population or housing units. Direct election of insurance commissioners may have contributed to growth as well, but this increase fails to attain statistical significance. Together these results indicate a possible significant role for insurance subsidies as driving coastal population growth. A land-falling hurricane did not slow growth during a decade, but counties with greater hurricane risk also grew significantly faster, which may be evidence that people ignore hurricane risk in making location decisions.

1. Introduction

Hurricane Katrina in August 2005 was the costliest natural disaster in U.S. history and brought national attention to the escalation of societal impacts of hurricanes. While Katrina garnered most of the attention, seven of the thirteen costliest hurricanes to strike the continental United States occurred in 2004 and 2005, and nine of the thirteen costliest hurricanes on record have occurred in the past twenty years (Blake, Rappaport and Landsea 2007). The hurricanes of 2004-05 illustrated the vulnerability of the insurance market to catastrophic losses, as well as the near certainty of generous government assistance after a disaster.

Increasing coastal populations drive much of the increase in hurricane costs. Figure 1 displays this growth, plotting the percentage of U.S. population residing in counties on the Atlantic and Gulf of Mexico coasts during the 20th Century. The coastal population has increased from 5.9 million to 35 million, and from 7.7 to 12.4 percent of U.S. population. This paper explores the sources of coastal population growth, specifically insurance policy, using a panel of Atlantic and Gulf coast counties from 1950 to 2000. Regulatory intervention in the insurance market takes numerous forms; since 1968 seven states have created residual markets or hurricane insurance pools for homeowners unable to attain insurance in the regulated market. The insurance pools seemingly provide a mechanism for insurance subsidies and inefficient coastal growth. But coastal county growth can result from other sources as well. For instance, considerable evidence suggests that people ignore low probability, high consequence events like hurricanes, and thus excessive exposure may result from biased decision making. Coastal population growth could also be a product of rising national wealth and may not involve inefficiency at all.

This paper attempts to discriminate between these hypotheses for growing hurricane vulnerability. I find a statistically significant and substantial impact of hurricane pools on the change in coastal county population and housing units, about 20,000 additional persons and 6,000 housing units per decade, consistent with increasing subsidies for coastal residents. But wind pools have little or no effect on the percentage change in coastal population or housing units. The election of insurance commissioners may also increase growth, although the effect is not statistically significant in regression analysis. I find that the impact of hurricane pools on coastal growth is mainly concentrated in the states which also have appointed insurance commissioners, which is consistent with elected commissioners catering to policy holders with below market rates for high risk properties. The counties subject to the greatest risk of a land-falling hurricane have indeed grown fastest, and this is consistent with excessive discounting of hurricane risk due to low probability event bias.

The remainder of this paper is organized as follows. Section 2 discusses the three competing hypotheses for growing hurricane vulnerability in greater detail. Section 3 discusses the measures of county growth employed here, based on both population and housing units, and the insurance market policies which could affect coastal growth. Univariate comparisons indicate that state hurricane or wind insurance pools and election of state insurance commissioners increase population and housing unit growth. Section 4 presents the regression results, and section 5 offers a brief conclusion.

2. The Growth of Coastal Populations

Economists have studied migration in an expected utility framework. An individual or household will migrate if the resulting increase in expected utility exceeds the cost of migration

(Sjaastad 1962).[1] For the case of a decision to live or operate a business on a hurricane exposed coast, individuals should compare the benefits of a coastal location with the extra costs due to damage from periodic hurricanes. The two main types of hurricane damage, storm surge flooding and wind damage, are concentrated along the coast, and thus safer locations will exist not too far inland. For a given quality of construction, expected hurricane damage is higher for coastal locations. The greater potential for loss could lead to investment in higher quality construction or perhaps enactment of stricter building codes in the coastal area, which will reduce property damage from hurricanes, compared to similar construction inland. Nonetheless, a coastal location entails higher costs than an inland location.

Households and businesses will locate in a hurricane prone coastal area if they perceive private net benefits relative to an inland location. The amenity of a coastal location is the primary benefit. Property owners or renters likely capture the amenity value of coastal living, so I ignore the potential for external benefits. But hurricane costs can be shifted to third parties, and property owners may misestimate, and most problematically underestimate, expected hurricane damage. Thus we can differentiate three different cases under which an individual or business may locate on a hurricane exposed coast:[2]

1. The benefits may exceed the costs of coastal development, which are entirely privately borne and accurately perceived. Coastal growth in this case is efficient.

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[1] For a discussion of economic models of migration as they relate to hurricanes and evacuation, see Landry et al. (2007).

[2] Development in coastal areas may create environmental costs like the loss of wetlands in addition to hazard related costs. This analysis focuses on total growth in coastal counties and not the important issue of where within the county the growth occurs, which will affect environmental costs.

2. Costs are completely internalized, but individuals underestimate the expected costs, due to low probability high consequence event bias or myopia, so benefits may exceed perceived costs but fall short of the true costs. Development in this case is inefficient.

3. Individuals accurately perceive expected hurricane costs, but some of the costs are shifted on to third parties, so benefits exceed private costs but are less than the full costs. Development in this case is inefficient.

The location decisions made by individuals and businesses determine the population of coastal counties. How do these alternatives explain the increase in coastal county populations and their growth relative to non-coastal areas?

Efficient coastal growth occurs when benefits exceed the full cost of hurricanes. In this case increasing populations result from increasing benefits, decreasing costs, or both. Rising national wealth would increase benefits or willingness to pay, as more and more Americans can afford to live or vacation near the ocean. Increasing wealth might fuel migration to coastal areas, and the counties which offer the greatest amenities, say the best beaches or urban areas, should grow the fastest among coastal counties. Improved hurricane forecasts reduce the cost of coastal living (Sadowski and Sutter 2005). Poorly monitored and forecast hurricanes might surprise residents and vacationers who are unable to evacuate. This was the case in 1900 in the Galveston, Texas hurricane, the deadliest hurricane in U.S. history, which struck the city without warning and killed an estimated 8000 persons. Effective warnings allow evacuation prior to landfall, eliminating (or drastically reducing) the risk of death and injury, and consequently reducing the full cost of coastal living.

Individuals might discount the possibility of a hurricane and thus underestimate the cost of a coastal location. Considerable evidence suggests that people treat the small annual probability of natural disasters like hurricanes as if it was zero (Camerer and Kunreuther 1989, Kunreuther 1996, Kunreuther and Pauly 2006). A prime example of low probability, high consequence event bias is the failure of people to insure against large losses, specifically not purchasing flood insurance available at subsidized rates (Kunreuther and Pauly 2004). The bias might result from a tendency of people to believe that such catastrophic events "won't happen to me," or they might have overconfidence regarding their ability to control circumstances if an event occurs, just as people tend to overrate their driving ability. The bias might also stem from cognitive dissonance, that one ignores hurricane risk if offered a lucrative a job in a coastal city.

The prevalence of low probability, high consequence event bias remains controversial in the face of low rates of insurance against large losses, because of counterveiling evidence of responses to low probability risks. The low probability event bias implies that *differences* in low probability risks should not affect behavior. Yet previous research has found housing market price differentials for natural hazards, consistent with expected utility theory and reasonably accurate perception of risks. For example, Brookshire et al. (1985) and Beron et al. (1997) found that homes in areas designated by the state of California as at high seismic risk sell at a discount, and that the size of the discount declined after the 1989 Loma Prieta earthquake. Shilling, Benjamin and Sirmans (1985), MacDonald, Murdock and White (1987) and Spreyer and Ragas (1991) found that homes located in flood plains in three different Louisiana cities sold at a discount of approximately 6% relative to comparable homes located out of the flood plain. Hallstrom and Smith (2005) and Carbone, Hallstrom and Smith (2006) found that the growth of house prices in areas of two coastal Florida counties (Miami-Dade and Lee) most susceptible to storm surge flooding slowed after Hurricane Andrew, consistent with a greater perceived risk of hurricanes. Evidence of market responses to natural hazards is significant in evaluating the prevalence of low probability event bias because factors other than bias can explain a failure to insure against natural hazards. The prospect of government or private disaster relief after a hurricane, as has occurred on a massive scale with Hurricane Katrina, could also explain a lack of action prior to the event.

Externalizing hurricane costs to third parties can also drive coastal growth. Hurricane damage can be externalized in a number of ways, including government and private disaster relief, the availability of property insurance at below market rates, and government funding of infrastructure (and its repair after a disaster) and structural hazard reduction measures like levees, sea walls and flood control projects. To explain increasing coastal populations, the proportion of costs shifted must have increased over time. Consequently this paper focuses on the potential impact of insurance subsidies on coastal growth. The availability of insurance at below market rates, either through government provided insurance as with the National Flood Insurance Program (NFIP), or through cross-subsidies in state regulation of the insurance market, also creates an externality. Since 1968 seven coastal states have established state run hurricane insurance pools to cover at a minimum wind and hail damage, while the NFIP was inaugurated in 1968. These represent two potential increases in insurance subsidies in recent decades, and could be contributing to increased societal vulnerability to hurricanes.

Note that these three factors are not mutually exclusive and could involve complex interactions. The impact of an insurance subsidy depends on the number of individuals and businesses on the affected margin. Initially policies which shifted twenty percent of hurricane damage to third parties might affect few location decisions, but with rising national wealth, the same subsidy might affect the location of many more individuals or businesses. All three factors have been linked with growing coastal populations. This paper attempts to test for the impact of these factors on the growth of coastal counties between 1950 and 2000.

3. State Insurance Regulation and Vulnerability

The main independent variables of interest reflect insurance regulation policy, specifically state hurricane insurance pools. Since 1968, seven Gulf and Atlantic coast states have established state run pools to offer insurance to coastal residents: Louisiana (1968), North Carolina (1969), Alabama (1970), Florida (1970), South Carolina (1970), Texas (1971), and Mississippi (1987). The basic structure of the pools involves state administered rates, coverage limits, and terms of coverage. All of the pools offer at a minimum wind and hail coverage, although the trend is to offer full homeowners coverage. The pools collect premiums and accumulate a surplus to cover losses when a hurricane results in extensive damage. The funds do not charge market rates and consequently do not accumulate reserves sufficient to cover losses from major hurricanes. When losses exceed accumulated reserves, the funds implement assessments on insurance policies written in the state. Membership in the hurricane pool is a condition of a company license to write coverage in the state. Assessments are apportioned across insurance companies based on premiums written on defined (assessable) lines of business in the state. Thus an insurer's share of assessments is roughly equal to its share of premiums in the state on defined lines. Insurers can be given credit for policies voluntarily written in coastal areas eligible for coverage under the pool. Assessments can generally be "passed" on to policy holders, although since the assessments are similar to an excise tax on premiums, the legal incidence does not affect the economic impact of assessments. In some states, assessments reduce a company's state tax payments. Some states rely on reinsurance to cover a portion of excess losses, but insurance companies can potentially face enormous assessments. As of early 2007, the seven hurricane pools had over 180,000 policies in force and total potential liability of $550 billion.

State hurricane pools effectively provide cross-subsidization of high risk properties in coastal areas, but post event assessments instead of above market premiums in low risk areas of the state comprise the transfer mechanism. State governments also might provide direct assistance to wind pools; Florida made a legislative appropriation to its insurance pool, Florida Citizens Property Insurance, after the hurricanes of 2004-05, and Louisiana issued $1 billion in revenue bonds to cover losses for Louisiana Citizens in 2006.

State hurricane insurance pools may be a source of increased subsidies for coastal living, yet their impact on rates may be marginal. States regulate the insurance industry in numerous ways, including control over rates, and regulators may suppress rates for high risk customers even without a hurricane pool. Nine of the 11 Atlantic coast states which do not have hurricane pools have Fair Access to Insurance Requirement (FAIR) plans (Maine and New Hampshire are the exceptions). FAIR plans are residual market mechanisms which provide insurance for homeowners and businesses which cannot obtain insurance in the voluntary market. States established FAIR plans under Federal authorizing legislation in the 1960s in response to cancellation of policies in cities following urban riots. The extent of high risk wind coverage and subsidies within these FAIR plans is difficult to judge, but the websites of the Georgia, New Jersey, New York and Virginia FAIR plans all have extensive information about wind coverage, while the Maryland, Massachusetts and Rhode Island plans describe restrictions on the issuance of new policies when a hurricane or tropical system is in the western Atlantic. These states may have sufficiently limited hurricane exposure to be able to subsidize high risk properties without a dedicated wind or hurricane pool. Thus states with hurricane pools might not offer greater subsidies than the other coastal states. In addition, the states with hurricane pools might have subsidized coastal properties prior to establishment of the pool. Thus the marginal impact of a hurricane pool on coastal populations *may* be modest.[3]

States regulate the insurance industry, and governors appoint insurance commissioners currently in 39 states. But some states elect insurance commissioners, and elected commissioners could easily pursue different policies than appointed commissioners. An insurance commissioner is a single issue contest, while appointment of an insurance commissioner is but one of numerous policy choices lumped together in a gubernatorial contest. Indeed, elected commissioners see more likely to protect domestic insurers relative to out-of-state companies (Meier 1991).[4] Elected commissioners might differ in their propensity to subsidize high risk coastal properties. As of 2000, six states along the Atlantic and Gulf coasts elected insurance commissioners.[5] Coastal residents could easily form an influential voting block in an insurance commissioner race, and certainly the coastal residents who benefit from subsidized insurance will be knowledgeable about insurance policies.

I examine two measures of coastal county growth, population and housing units.

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[3] An impact of hurricane pools on growth may be a result of credibly signaling a long term commitment to subsidized premiums as much as necessarily lower premiums relative to states' FAIR plans or regulated insurance markets.

[4] For theoretical treatments of why elected regulators might behave differently from appointed commissioners, see Spiller (1990) and Besley and Coate (2003). For evidence of an impact in traditional public utilities regulation see, while Ruhil and Teske (2003) finds that elected insurance commissioners regulate solvency differently than appointed commissioners.

[5] Florida combined its insurance commissioner's duties with the appointed chief financial officer position effective as of 2002, so it had an elected insurance commissioner throughout the

Population is the most commonly studied measure of vulnerability, and reflects the potential for loss of life and property damage from future hurricanes. Census population figures reflect the main residence of households, and so do not include part-year residents or tourists. Rental property constitutes societal vulnerability, and an area with many condominiums or rental properties might have substantial property and many part year residents at risk yet have a small and stable permanent population as counted by the Census. My dependent variables are the change in population and housing units in a county between decennial censuses, *Difference Population* and *Difference Units*, and the percentage changes in these measures, *Percent Population* and *Percent Housing Units*. Whether the change in the number of persons or the percentage change in persons represents a better measure of societal vulnerability is debatable. At the least, growing populations over time tend to make similarly large percentage changes in population less likely.

Table 1 displays summary statistics for the four measures of societal vulnerability, as well as the other variables discussed in the next section. The data set includes all counties on the Atlantic Ocean and Gulf of Mexico coasts of the U.S. I do not include counties with coast exposure only along bays or tidal rivers, for instance, along the Chesapeake Bay or Delaware Bay.[6] I do include counties in Connecticut and on the coast in the New York City area. My sample includes the five decades between 1950 and 2000, the post World War II period. The county decade is the unit of observation. I exclude counties with substantial boundary changes during the period, primarily in the Hampton Roads area of Virginia. The panel consists of 121

period of this study.

[6] Thus I do not consider coastal zone counties as defined by NOAA. My interest is in the potential development for the high wind risk properties near the shore, where dense high value

counties for a total of 605 observations. The largest proportion of coastal counties are in Florida (34), followed by Texas (14), Louisiana (11), and North Carolina (8), with 32 percent of the 2000 population in Florida, followed by 23 percent in New York. The mean population change was an increase of 31,400 persons, with a range from an increase of 627,000 persons to a decrease of 371,000 persons. The average county had an increase of 16,350 housing units over the period, with a range from a 21,200 decrease to a 233,000 unit increase. The mean of county population growth rates was 28% over the period, with a range from a 23% decline to a 371% increase, with a mean 38% increase in units with a range from a 19% decrease to 289% increase. Figures 2 and 3 display the distribution of changes in population and housing units observed over the panel. Decreases in housing units were not as common as decreases in population. Growth in population and housing units is obviously correlated, with correlations of +.874 for changes and +.922 for percentage changes. But the measures do not coincide. Housing units increased by 200% and population by 125% over the period, for a difference of 75 percentage points. Eighty six counties had growth rates in housing units that exceeded population by either more than 100 points or less than 50 points.

Table 2 reports differences in mean values of population and housing unit growth for counties in decades with hurricane pools and for counties when hurricane pools were not in place. For the six states which established pools between 1968 and 1971, *Hurricane Pool* equals 0 for the 1950s and 1960s and then 1 for the 1970s, 1980s and 1990s, while for Mississippi counties, *Hurricane Pool* = 1 only for the 1990s. Counties grew faster in decades with hurricanes pools in place. The mean population change was a 35,250 person increase in counties in states with pools compared with a 29,130 person increase in counties without pools, a

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development often occurs.

difference of 21%. The counties during decades with hurricane pools had a mean increase of 19,940 housing units, compared with a mean increase of 14,220 units in counties without pools, or a 40% larger mean increase. Counties with hurricane pools also grew faster in percentage terms, 29.7% to 27.4% for population and 43.0% to 34.2% for housing units, but the increase in growth is more modest in magnitude. Table 2 next reports the mean values for the 77 counties in hurricane pools for the decades immediately prior to and following the establishment of the pool. Such a comparison controls for amenities as well as for longer term demographic changes in the nation as a whole. These counties grew significantly faster after the hurricane pools were established, with population growth about 60 percent larger in the subsequent decade and growth in housing units was 140 percent larger. The percentage changes for population were 26% before against 42% after and for housing units 34% in the preceding decade and 69% after.

The last part of Table 2 compares growth in states with appointed and elected insurance commissioners. Coastal growth has been significantly faster in states with elected commissioners: average decade population growth of 35,800 versus 26,800 and average decade housing unit increase of 18,000 and 14,600 respectively. The difference in growth is also pronounced in percentage terms, 40% to 15% for population and 51% to 23% for housing units. Faster growth in states with elected commissioners is consistent with greater cross-subsidies in rate structures when commissioners seek to win votes directly, consistent with Besley and Coate (2003) who argue that elected regulators should be more proconsumer.

4. Regression Analysis

I now turn to regression analysis to confirm if the mean differences observed in Table 2 associated with hurricane pools and elected insurance commissioners hold up when controlling for other determinants of growth. The analysis includes a number of control variables. One variable included in all of the models is the lagged growth in population or housing units. Growth in a county is likely to be correlated over time, and thus lagged growth can control for county specific factors. Another control variable is *Density*, the population density in thousands of persons per square mile at the beginning of the decade. The beginning population, scaled by land area, measures both the desirability of the area and the extent of prior building, which could affect the amount of undeveloped land remaining in the county and the potential for future growth. Consequently *Density* could either increase current growth if it signals amenities or decrease growth if reflecting escalating land prices. *Percent White* controls for the impact of racial preferences on the desirability of a coastal county as a potential place to live or vacation. *Percent Urban* controls for whether a county possesses the amenities of urban living in addition to the attraction of the coast. If proximity to urban living is an amenity, *Percent Urban* will have a positive sign, but urbanization could also drive up land prices and divert growth to other coastal areas. *State Population* is the percentage growth of the non-coastal counties of the state during a decade. This variable controls for factors affecting the overall desirability of a state during a decade and not just the coastal areas. If all counties in Florida, say, are growing fast, growth in the coastal counties of Florida is probably not being driven by coastal policies. State tax and spending policies, for instance, could be captured by this variable. *Major* is a dummy variable which equals one if a county was struck by a major hurricane, that is, one rated category 3 or higher on the Safir-Simpson scale of hurricane intensity during the decade and zero otherwise. About 16 percent of county decade observations experienced major hurricanes. A hurricane could reduce growth during a decade through two channels, one by diverting resources from new construction to rebuilding, and two by affecting perception of hurricane risk and desirability of the area. Galveston, Texas, provides an example of a city affected long term by a major hurricane. Prior to the 1990 hurricane, Galveston was a rival of Houston as the main port on the Texas coast, and Galveston's population was 85 percent as large as Houston's. By 1910, Galveston's population was only 47 percent of Houston's, and in 2000, Houston was 34 times larger than Galveston. *Probability Major* is the annual probability of landfall of a hurricane rated category 3 or stronger on the Safir-Simpson scale in the county, constructed from hurricane climatology data reported on the website of the National Hurricane Center. The mean annual probability of a major hurricane is .004, ranging from less than .001 to over .2 in South Florida.[7] A higher probability of a major hurricane increases the expected hurricane losses, and should reduce growth in a county, if people do not suffer from low probability, high consequence event bias. On the other hand, the probability of a major hurricane is constant over time and varies geographically and could potentially capture some of the desirability of counties with greater hurricane exposure.[8] The regression models include decade dummy variables to control for national factors affecting potential coastal growth during a decade, for instance, macroeconomic conditions or rising national wealth which might facilitate migration to coastal locations, or the introduction of air conditioning. Finally, the models include state dummy variables, which control for state specific conditions which do not vary over the sample period which might affect coastal growth. The state variables control for differences in amenity values, since the Florida dummy variable can control for the general attraction of the state. The state variables can also

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[7] These values are not given for every county along the coast, but instead for different locations along the coast. Counties were assigned the nearest value, or the average of two values if approximately equidistant from two locations where the probability is reported.

[8] Similar variables are also constructed for *Any Hurricane* to strike the county and

control for elements of state policy which might affect the attractiveness of the state as a whole to new residents or businesses that are unchanged over time. The results reported in this paper use panel corrected standard errors.

Table 3 examines the role of *Hurricane Pools* on coastal county growth. Two specifications for *Difference Population* and *Difference Units* are reported, with the second including *State Population* as a control. Establishment of a hurricane pool in a state is a statistically significant and quantitatively important determinant of county growth in three of the four specifications. In column (a), a pool increases the growth in population by an estimated 23,300 persons per decade, which is significantly different from zero at better than the 10% level. The regression estimate is substantially larger than the 6,000 person difference identified in the mean comparisons in Table 2, is almost equal to the mean decade increase in county population over the period, and is equal to about one third of the standard deviation. The estimate in (b) with *State Population* is smaller, 16,200 persons per decade. Most state wind pools were inaugurated around 1970, and thus the total effect over three decades is an estimated extra 50,000 to 70,000 persons due to the establishment of the pool. In column (c), a hurricane pool increase housing units in a county by about 6,400 per decade, which is also significant at better than the 10% level. The point estimate is just less than the difference in the mean comparison from Table 2, and equals about 35 percent of the mean decade change in housing units, about 25 percent of the standard deviation in the change in housing units. The estimated impact in (d) is again slightly reduced, or 4,500 additional housing units per decade, and that this

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Probability Hurricane based on any hurricane strike.

estimate fails to attain significance at the 10% level.[9]

The control variables have broadly similar effects across specifications. In no instance does the sign of significant coefficients change across the four specifications. One control variable which is significant (at better than the 1% level) in each specification is the lagged population or housing unit growth, which increases current growth as expected. About 50% of the previous decade's change in population persists to the current decade, while just over 60% of the housing unit increase persists. *Probability Major* also significantly increases growth in each specification. The impact is also quantitatively large, with a one standard deviation increase in hurricane risk increasing population growth by 20,000 persons and housing growth by 7,000 units per decade. Counties subject to the greatest hurricane risk have grown faster. Everything else equal, a higher hurricane landfall probability increases the cost of coastal living and should slow growth, so the positive sign on *Probability Major* may indicate that Americans exhibit low probability event bias as described by Camerer and Kunreuther (1989) and Kunreuther and Pauly (2004) and disregard the possibility of a hurricane. But low probability event bias actually predicts that *Probability Major* should be unrelated to growth; thus the positive sign on *Probability Major* may capture otherwise unmodeled local amenities, particularly for counties in South Florida with the greatest hurricane risk.[10] *Percent White* is not a significant determinant of

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[9] Louisiana is the one coastal state without a well developed coastline, but instead largely has bayous along its gulf coast. Since Louisiana's coast is not developed, an argument could be made for excluding the state from the analysis. The regressions in Table 3 were run excluding Louisiana, which modestly increased the magnitude of the *Hurricane Pool* effect.

[10] The models were also estimated with variables controlling for the landfall of any hurricane over the decade and the probability of landfall of any hurricane in place of the variables just for major hurricanes. The estimated impacts of these variables for all hurricanes were slightly smaller than those for major hurricanes, as intuition suggests, and differences in the

population or housing unit growth, and so the racial composition of a county does not affect (significantly) the growth of a county. *Percent Urban* is significant in each specification, with a more urban population increasing growth, consistent with an urban amenity effect. *Density* has a negative point estimates consistent with crowding reducing growth, but fails to attain statistical significance. A hurricane during the decade had little impact on contemporary growth, as *Major* never attains significance, and the point estimates are small in magnitude as well. The decade dummy variables are generally individually significant and always jointly significant, with negative signs each time, indicating smaller growth in subsequent decades relative to the omitted category of the 1950s once controlling for other determinants of growth. The state dummy variables are highly jointly significant.[11]

Table 5 presents the analysis of the percentage change in coastal county population and housing units. The same four specifications for the changes in population of housing units are presented. While a *Hurricane Pool* increases the change in the number of persons or housing units, it reduces the percentage change, albeit only attaining significance one time. *Hurricane Pool* has small point estimates in the specifications which do not include *State Population*; with *State Population* included, *Hurricane Pool* reduces the percentage change in population and housing units by 8.4 and 8.5 percentage points each, although only the former estimate attains significance (at the .05 level). The previous decade's percentage growth in a county significantly increases the current decade's growth in each specification, with between 40 and 50% of the

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coefficients of the other variables were so minor to not merit reporting here. The fit of the models was slightly poorer with the all hurricanes variables, so the results with major hurricanes are reported here.

[11] Following Sadowski and Sutter (2005), a variable controlling for the lethality of hurricanes interacted with *Probability Major* was included as a control variable, but failed to

growth persisting to the next decade. *State Population* is a significant (at the .01 level) determinant of both population and housing. The coefficients on *State Population* exceed one, indicating that a one percentage point growth in the population of the non-coastal counties of the state increases coastal county growth by more than one percentage point. In this sense, growth in a state as a whole is amplified in coastal areas. The other significant determinants of percentage changes are *Density*, which reduces the growth in *Housing Units*, and *Percent Urban*, which reduces the percentage change in the specification for *Housing Units* which includes *State Population*. The decade dummy variables again are significant determinants of growth, with growth in the 1960s, 1980s and 1990s being slower than in the 1950s, the omitted category. The 1970s witnessed slower growth in population but faster growth in housing units, relative to the 1950s. Overall the goodness-of-fit of the models of percentage growth is notably lower than for the models of the change in population or housing units in Table 3.

Table 5 investigates the role of state insurance commissioner selection on coastal growth. Election of state administrative offices like insurance commissioners stems from early in the Twentieth Century, and thus states rarely change the method of commissioner selection. Consequently, since no sate in this panel changed their method of selection during the period, state dummy variables cannot be included when *Elected* is included as an independent variable.[12] The first two columns of Table 5 then present specifications of the difference in population and housing units including *Elected* as a control variable. State variables control for differences in amenities, and particularly climate factors, and so these specifications are deficient in this regard.

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attain significance.

[12] California was the most recent state to adopt election of the insurance commissioner, in 1990, but is not in my sample. Florida's first appointed insurance commissioner took office in

Also *Probability Major* is omitted in these specifications, since this variable would capture some of the state fixed effects and thus be difficult to interpret. These specifications merely hint at a possible impact of state insurance commissioner election. *Elected* increases coastal county growth, although the effect is modest compared with the difference in means reported in Table 2 and fails to attain significance. In the difference specifications in columns (a) and (b), counties in states with an elected commissioner grew by an extra 4,100 residents and 2,200 housing units per decade, or about 2% and 3% of the mean beginning county population and housing stock. *Hurricane Pool* continues to increase growth, but the magnitude of its effect is reduced and the variable no longer attains significance in these specifications. The signs and significance of the other control variables resemble Table 3.

The final two columns of Table 5 present the difference in population specification from the first column of Table 3 estimated separately for states with elected and appointed insurance commissioners; note that these specifications do include state dummy variables for the included states. The impact of a *Hurricane Pool* will depend on the regulation of the insurance market. Thus a residual market mechanism may not necessarily lead to lower premiums for wind coverage than observed in the regular market, and consequently may not affect growth. The last two specifications of Table 5 reveal that the effect of *Hurricane Pool* differed substantially across the elected and appointed commissioner states. *Hurricane Pool* significantly increased (at the .05 level) population growth in the appointed commissioner states (Alabama, South Carolina and Texas), by about 32,300 persons per decade. By contrast, the point estimate of *Hurricane Pool* is close to zero and does not approach significance in the elected commissioner states. Economic theory suggests that elected commissioners will regulate in a more pro-consumer

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2003.

fashion (Besley and Coate 2003); my results are consistent with this pattern. If states with elected commissioners already set premiums below market for high risk insurance, the marginal effect of a hurricane pool could easily be close to zero. The signs and significance of several control variables differ between appointed and elected commissioner states. Lagged population growth is significant only in the elected commissioner states, while *Probability Major* is also significant only in elected states. *Percent Urban* increases population change only attains significance in the elected commissioner states.

5. Conclusion

Increasing societal vulnerability to hurricanes, defined as more persons and property in at-risk coastal areas, is the primary source of rising damages from hurricanes. A positive time trend in damage disappears when controlling for changes in coastal population and wealth in addition to inflation are controlled for (Pielke and Landsea 1998). Consequently to understand rising hurricane losses (and the potential for even greater losses from catastrophes for from an elevated rate of Atlantic hurricane activity), causes of coastal population growth must be understood. Increased vulnerability is not necessarily inefficient, and may simply reflect a wealthier society in which more people can afford to live or vacation near the ocean. Increasing coastal populations, however, could be a product of low probability, high consequence event bias, or result from government policies shifting some of the cost to taxpayers or insurance policy holders, in which cases population growth could be inefficient. Policies limiting coastal growth and development may raise or lower welfare, depending on why coastal counties are growing.

This paper has attempted to discriminate between these three explanations for coastal growth. State hurricane insurance pools appear to have increased the absolute number of persons and number of housing units in coastal counties. Thus between 1970 and 2000, the period of existence for most of the state hurricane pools, the pools might account for growth equal to 40 percent or more of 1970 population and housing stock. But the result does not hold for the percentage change in population or housing units. The election of state insurance commissioners might have contributed to substantial coastal county growth. Besley and Coate (2003) argue that elected regulators will be more pro-consumer and my results here suggest elected insurance commissioners may be pro-high risk consumers. Together the impact of these policies suggest an important role for below market insurance rates, and particularly a commitment to subsidies through the establishment of residual market mechanisms, as contributing to growth. Growth has also been faster in counties facing the greatest risk of hurricane landfall, which is consistent with individuals ignoring hurricane risk in their location decisions due to low probability event bias, but which could also be due to hurricane risk reflecting unmodeled amenity values of high risk counties.

References

Beron, K. J, Murdoch, J. C., Thayer, M. A., and Wim P. M Vijverberg, W. P. M.. (1997) An Analysis of the Housing Market Before and After the 1989 Loma Prieta Earthquake. *Land Economics*, 73: 101-113.

Besley, Timothy, and Stephen Coate. 2003. “Elected versus Appointed Regulators: Theory and Evidence.” *Journal of the European Economic Association*, 1(5):1176-1206.

Blake, Eric S., Edward N. Rappaport, and Christopher W. Landsea. 2007. “The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2006 (and Other Frequently Requested Hurricane Facts).” National Hurricane Center, Miami, available on-line at http://www.nhc.noaa.gov/pdf/NWS-TPC-5.pdf.

Brookshire, David S., Thayer, Mark A., Tschirhart, J., and Schulze, William D.. (1985) “A Test of the Expected Utility Model: Evidence from Earthquake Risks. *Journal of Political Economy*, 93: 369-389.

Camerer, Colin, and Kunreuther, Howard. (1989) Decision Processes for Low Probability Events: Policy Implications. *Journal of Policy Analysis and Management*, 8: 565-592.

Carbone, Jared. C., Hallstrom, Daniel G., and Smith, V. K. (2006) Can Natural Experiments Measure Behavioral Responses to Environmental Risks? *Environmental and Resource Economics*, 33(3): 273-292.

Hallstrom, Daniel G., and Smith, V. Kerry. (2005) Market Responses to Hurricanes. *Journal of Environmental Economics and Management*, 50(3): 541-561.

Kunreuther, Howard. 1996. “Mitigating Disaster Losses through Insurance.” *Journal of Risk and Uncertainty*, 12: 171-187.

Kunreuther, Howard, and Mark Pauly. 2004. “Neglecting Disaster: Why Don’t People Insure Against Large Losses?” *Journal of Risk and Uncertainty*, 28(1):5-21.

Kunreuther, Howard, and Mark Pauly. 2006. “Rules Rather than Discretion: The Lessons from Hurricane Katrina.” *Journal of Risk and Uncertainty*, 33(1-2): 101-116.

Landry, Craig E., Okmyung Bin, Paul Hindsley, John C. Whitehead, and Kenneth Wilson. 2007. “Going Home: Evacuation-Migration Decisions of Hurricane Katrina Survivor.” *Southern Economic Journal*, forthcoming.

MacDonald, D. N., Murdock, J. C. and White, H. L. (1987) Uncertain Hazards, Insurance, and Consumer Choice: Evidence from Housing Markets. *Land Economics*, 63: 361-371.

Meier, Kenneth J. 1991. “The Politics of Insurance Regulation.” *Journal of Risk and Insurance*, 58(4): 700-713.

Pielke Jr., Roger A., and Christopher W. Landsea. 1998. "Normalized Hurricane Damages in the United States." *Weather and Forecasting*, 13:621-631.

Ruhil, Anirudh V. S., and Paul Teske. 2003. "Institutions, Bureaucratic Decisions, and Policy Outcomes: State Insurance Solvency Regulation." *Policy Studies Journal*, 31(3):353-372.

Sadowski, Nicole Cornell, and Daniel Sutter. 2005. "Hurricane Fatalities and Hurricane Safety: Are Safer Hurricanes More Damaging?" *Southern Economic Journal*, 72(2):422-432.

Shilling, J. D., John D. Benjamin, and C. F. Sirmans. 1985. "Adjusting Comparable Sales for Floodplain Location." *Appraisal Journal*, 53: 429-436.

Sjaastad, Larry A. 1962. "The Costs and Returns of Human Migration." *Journal of Political Economy*, 70(5, pt2): 80-93.

Spiller, Pablo. 1990. "Politicians, Interest Groups, and Regulators: A Multiple-Principals Agency Theory of Regulation, or 'Let Them Be Bribed.'" *Journal of Law and Economics*, 33(1):65-101.

Spreyer, J. F., and Ragas, W. R. (1991) Housing Prices and Flood Risk: An Examination Using Spline Regression. *Journal of Real Estate Finance and Economics*, 4: 395-407.

Figure 1

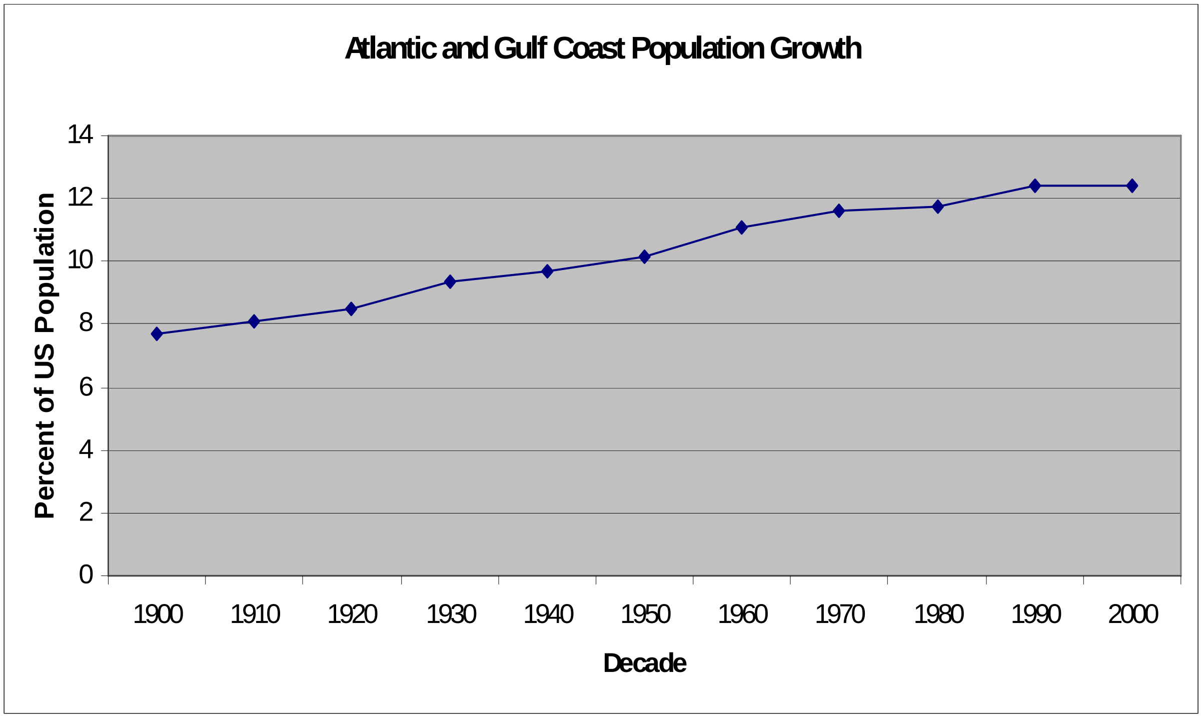
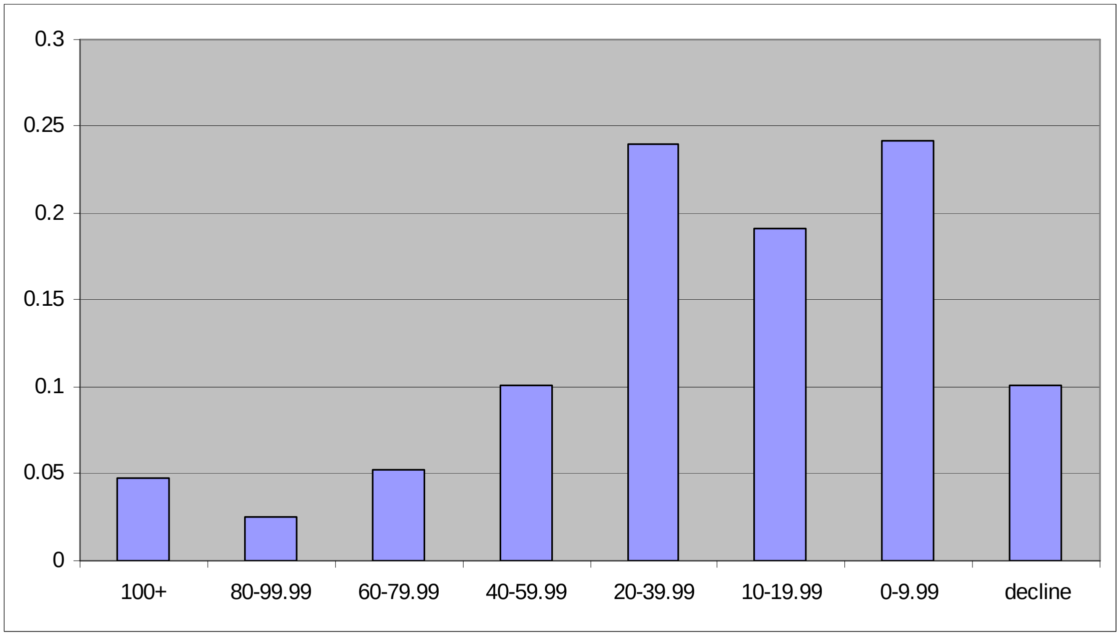

Atlantic and Gulf Coast Population Growth
Percent of US Population
0
2
4
6
8
10
12
14
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Decade

Figure 2: Distribution of Decadal Population Changes



Note: County population changes in thousands of persons

Figure 3: Distribution of Decadal County Housing Unit Changes

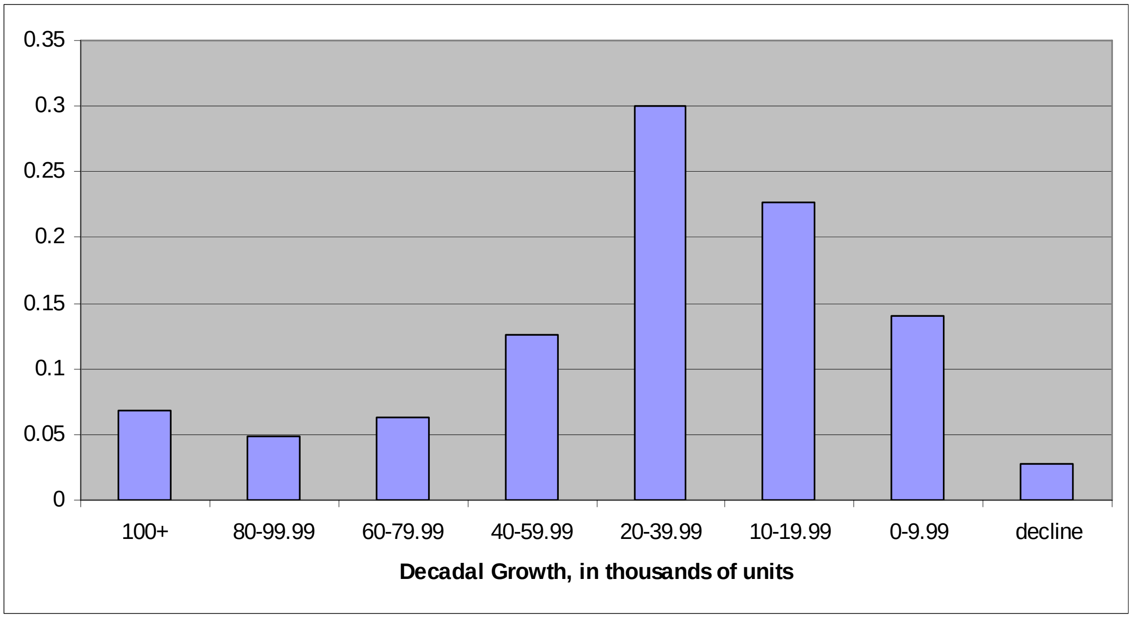


Table 1: Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Difference Population	31.41	68.94	-371.1	627.4
Difference Housing Units	16.35	27.08	-21.22	232.8
Percentage Population	28.26	37.41	-23.30	371.1
Percentage Housing Units	37.51	38.32	-18.91	288.9
Hurricane Pool	.3709	.4834	0.0	1.0
Elected	.5132	.5002	0.0	1.0
Density	.9013	3.798	.000316	39.12
Percent White	.8243	.1394	.3492	1.0
Percent Urban	.5349	.3700	0.0	1.0
State Population	18.97	14.29	-3.044	51.41
Major Hurricane	.1589	.3659	0.0	1.0
Probability Major	.0443	.0335	.0007	.2039

Table 2: Insurance Regulation and Coastal County Growth

	Population		*Units*	
	Difference	*Percent*	*Difference*	*Percent*
Full Sample				
Hurricane Pool	35.23	29.74	19.94	43.03
No Pool	29.13	27.38	14.22	34.23
Counties in States with Hurricane Pools				
Decade Prior Establishment of Pool	23.74	25.69	10.24	34.46
Decade Following Establishment of Pool	36.50	41.86	24.06	69.01
State Insurance Commissioner, Full Sample				
Elected	35.80	39.82	18.00	51.00
Appointed	26.79	15.16	14.60	23.38

Table 3: Regression Analysis of Coastal County Growth

	Difference Population		*Difference Units*	
Constant	29.9**	-.947	-.263	-8.43
	(2.20)	(0.06)	(0.05)	(1.48)
Lagged Difference	.508***	.523***	.626***	.636***
	(2.67)	(2.74)	(3.41)	(3.48)
Hurricane Pool	23.3***	16.2*	6.38*	4.46
	(1.83)	(1.78)	(1.90)	(1.29)
Density	-3.60	-3.47	-.428	-.411
	(1.16)	(1.11)	(1.03)	(0.99)
Percent White	-34.2	-31.5	3.17	3.91
	(1.30)	(1.22)	(0.38)	(0.46)
Percent Urban	12.2*	10.8	5.42*	5.00
	(1.65)	(1.45)	(1.71)	(1.63)
State Population		1.22***		.365*
		(2.71)		(1.72)
Major	4.42	2.78	2.10	1.67
	(0.81)	(0.47)	(1.05)	(0.81)
Probability Major	655***	644***	198**	194**
	(3.43)	(3.38)	(2.21)	(2.19)
D1960	-15.9***	-4.04	-7.81***	-4.63**
	(4.33)	(0.89)	(6.22)	(2.17)
D1970	-31.8***	-23.4***	.0382	2.29
	(3.69)	(3.67)	(0.02)	(0.89)
D1980	-26.0***	-11.3	-9.74***	-5.91*
	(3.21)	(1.63)	(3.32)	(1.72)
D1990	-23.4**	-7.17	-12.5***	-8.20**
	(2.81)	(1.01)	(4.91)	(2.45)
Adjusted R^2	.564	.573	.691	.695

n = 605. Absolute t-statistics in parentheses based on panel corrected standard errors. *, ** and *** indicate significance at the 10%, 5% and 1% levels. Models include state dummy variables.

Table 4: Regression Analysis of Coastal County Growth

	Percent Population		*Percent Units*	
Constant	22.1	-12.6	26.0	-5.51
	(1.33)	(0.78)	(1.55)	(0.34)
Lagged Percent	.421*	.444**	.626**	.463**
	(1.83)	(2.22)	(2.28)	(2.45)
Hurricane Pool	-.785	-8.38**	-1.57	-8.49
	(0.08)	(2.22)	(0.14)	(1.41)
Density	.775	-.707	-.556*	-.504*
	(1.64)	(1.55)	(1.81)	(1.77)
Percent White	5.72	6.86	2.07	3.85
	(0.23)	(0.31)	(0.08)	(0.17)
Percent Urban	-6.87	-8.10	-10.1	-11.1*
	(0.88)	(1.07)	(1.57)	(1.77)
State Population		1.41***		1.25***
		(6.78)		(4.31)
Major	-3.13	-5.02	-.0442	-1.77
	(1.14)	(1.56)	(0.02)	(0.54)
Probability Major	102	99.1	94.3	93.9
	(1.04)	(1.02)	(0.95)	(0.94)
D1960	-31.0***	-17.4***	-30.6***	-18.2***
	(7.23)	(4.54)	(11.3)	(4.95)
D1970	-31.8*	-2.16	9.11	17.8***
	(1.81)	(0.68)	(1.24)	(3.72)
D1980	-26.5***	-9.96***	-27.8***	-13.1**
	(4.26)	(2.94)	(3.55)	(2.08)
D1990	-24.9***	-6.26	-28.8***	-12.2**
	(3.79)	(1.50)	(3.94)	(2.09)
Adjusted R^2	.408	.455	.504	.539

n = 605. Absolute t-statistics in parentheses based on panel corrected standard errors. *, ** and *** indicate significance at the 10%, 5% and 1% levels. Models include state dummy variables.

Table 5: Insurance Pools, Insurance Commissioners, and Coastal County Growth

	Difference Population	*Difference Units*	*Elected = 1*	*Elected = 0*
Constant	8.95	-11.1	28.2	64.2*
	(0.67)	(0.28)	(1.63)	(1.66)
Lagged Difference	.689***	.776***	.832***	.308
	(3.69)	(4.31)	(5.92)	(1.25)
Hurricane Pool	7.20	2.52	.749	32.3*
	(0.68)	(0.96)	(0.12)	(2.16)
Elected	10.6**	6.40***		
	(2.05)	(3.18)		
Density	-.821	-.0827	-10.8	-5.06
	(0.28)	(0.14)	(1.54)	(1.52)
Percent White	5.37	7.05	-15.0	-61.5
	(0.30)	(1.53)	(0.48)	(1.04)
Percent Urban	17.9*	5.81	7.71*	16.0
	(1.86)	(1.52)	(1.81)	(1.11)
Major	2.75	1.27	3.06	7.97
	(0.38)	(0.50)	(0.67)	(0.65)
Probability Major			350**	130
			(2.58)	(1.05)
D1960	-20.0***	-8.87***	-20.7***	-14.6***
	(5.91)	(7.62)	(7.29)	(3.66)
D1970	-25.5***	1.66	-3.60	-48.1***
	(3.64)	(0.94)	(0.73)	(8.08)
D1980	-18.4***	-9.48***	-15.1***	-34.7***
	(2.84)	(3.69)	(2.81)	(5.06)
D1990	-16.1**	-11.6***	-13.9**	-26.3***
	(2.45)	(5.47)	(2.45)	(5.13)
Adjusted R^2	.498	.660	.817	.380

n = 605. Absolute t-statistics in parentheses based on panel corrected standard errors. *, ** and *** indicate significance at the 10%, 5% and 1% levels. The last two specifications include state variables.