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Wind Insurance and Mitigation in the Coastal Zone

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Abstract

This paper presents one of very few analyses of the decision to undertake wind mitigation measures, and the only study to analyze the decision to purchase wind coverage for individuals whose standard homeowner's policy excludes wind. A simultaneous mixed-process approach is used that allows for correlated disturbances across probit (insurance) and tobit (mitigation) equations. Results indicate a positive correlation between the errors of the insurance and mitigation models; conditioning on covariates, households that hold wind insurance tend to engage in greater levels of wind mitigation. Thus, the data imply two types – households that purchase insurance and mitigate and others that do neither.

Keywords: mitigation, risk preferences, risk perceptions, wind insurance, wind pool

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Introduction

Coastal properties along the Atlantic and Gulf coasts are at risk both to wind and flood damages due to tropical storms and hurricanes. Although the source of risk is the same (hurricanes), mitigation measures and insurance products to address wind and flood peril differ. Flood mitigation generally focuses on elevation of the property, along with other water-proofing measures. Wind mitigation involves steps to increase the structural soundness of the property, such as installation of storm shutters, reinforcing doors and windows, and the use of particular roof designs and attachments that reduce the risk of the roof being blown off.

Regarding insurance, coverage for flood peril is almost universally excluded from standard residential and commercial property insurance policies offered by private insurers, and offered instead through the National Flood Insurance Program (NFIP). Although coverage for wind peril is generally included in standard property policies, in many coastal areas at high risk of wind damage due to tropical storms and hurricanes, wind coverage is excluded. Property owners who still wish to have such coverage must purchase either a separate wind-only policy from a private insurer or, as is more often the case, obtain coverage through state-run insurance programs (Kousky 2011; U.S. GAO 2008).

We find that although there are many studies in the literature focused on hurricane mitigation and insurance, they are by and large focused on *flood* mitigation and insurance, with relatively little written with regard to *wind* mitigation and insurance. The only exception that appears to focus specifically on wind damage mitigation is Carson, McCullough, and Pooser

(2013).[1] The present study differs from Carson, McCullough, and Pooser, however, in that we use household-level survey data, which includes risk perception and risk preference information. Second, to our knowledge, there is *no study* that examines the decision to buy wind coverage when it is excluded from one's regular homeowner's policy. Thus, we offer the only known analysis focused on the decision to purchase wind coverage.

The analysis utilizes data from a 2010 survey of coastal homeowners in Alabama, Florida, Louisiana, Mississippi, and Texas. The survey focuses on mitigation and insurance decisions, perceptions, and preferences regarding both flood and wind risk stemming from hurricanes. Results indicate that respondents living in areas where wind peril is excluded from regular homeowner policies, i.e., where wind risk is highest, actually tend to undertake fewer mitigation activities. Also, those who buy wind-only policies also tend to undertake more mitigation activities. Respondents who have experienced storm damage in the past as well as those living in the coastal zone are both more likely to buy a wind-only policy and to undertake more mitigation. The rest of the paper is organized as follows: a review of the literature on hurricane mitigation and insurance research, an overview of state-run insurance programs, an overview of the survey instrument and data, a discussion of our conceptual and empirical models, regression results, and a summary and conclusions.

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[1] Simmons, Kruse, and Smith (2002) also focus on wind damage mitigation but they focus on the impact of the wind damage mitigation on the resale value of the property rather than the decision to mitigate.

Literature Review

There are many studies in the literature about flood insurance. Generally, flood coverage is excluded from property insurance, and property owners in the U.S. can purchase flood insurance through the NFIP (U.S. GAO 2008). There are various studies that identify factors affecting the probability of an individual purchasing flood insurance. Browne and Hoyt (2000) find that demand for flood insurance decreases as price increases and increases as income increases. U.S. GAO (1983), Dixon et al. (2006), and Kriesel and Landry (2004) find that demand for flood insurance is price inelastic. Kriesel and Landry (2004) also find that the probability of an individual purchasing flood insurance increases for mortgaged properties and in communities with erosion protection projects, and decreases as the distance from the shoreline and the historical interval between hurricanes increase.

In contrast, Landry and Jahan-Parvar (2011) find that individuals with mortgage contracts do not hold greater flood insurance coverage, and only twelve percent of homeowners in the coastal Special Flood Hazard Area claim they were required to purchase flood insurance by their lender. They find that flood insurance coverage is greater in areas of greater flood and erosion risk. Petrolia, Landry, and Coble (2013) empirically test the role of risk preferences and risk perception in flood insurance decisions. They find that risk aversion and expected damages from hurricanes are positively correlated with the decision to purchase flood insurance. They also find the credibility of insurers correlates positively with purchasing flood insurance. Several studies also find an increase of past flood damage experience increases the probability of holding flood insurance (Baumann and Sims 1978; Kunreuther 1978; Brown and Hoyt 2000; Kriesel and Landry 2004; Carbone, Hallstrom, and Smith 2006; Petrolia, Landry, and Coble 2013).

Aside from formal insurance arrangements, property owners can engage in mitigation activities to manage the risk of hurricane damage. Ehrlich and Becker (1972) classify mitigation activities as either self-protection - measures that aim to reduce the probability of loss (such as elevating a structure or relocating to a lower wind-risk zone) - or self-insurance - measures that reduce the severity of loss (such as water-proofing a structure or installing storm shutters). As self-protection is often infeasible, many studies in the literature focus on self-insurance. Simmons, Kruse, and Smith (2002) find that property values in high wind-risk zones capitalize the value of storm shutters. Dumm, Sirmans, and Smersh (2011) find that homes built under newer building codes that require mitigation activities sell more than otherwise similar homes. Kunreuther and Kleffner (1992) argue that property owners engage in mitigation activities not only for self-insurance, but also for personal self-protection - to prevent injury or death. Hatori et al. (2004) claim that households may partly base their mitigation decisions on social norms - in particular, observing the actions of their neighbors.

Carson, McCullough, and Pooser (2013) identify factors affecting household mitigation decisions in Florida. They find that the likelihood of obtaining a mitigation loan is positively correlated with the number of openings in the home, the age of the property, household income, property value, and the percentage of neighbors participating in the My Safe Florida Home program. They find that the number of children in the household also increases mitigation likelihood, as does the level of wind insurance premium (suggesting that premium discounts can provide an incentive for mitigating). They find similar results for the level of mitigation expenditures. There are also studies that find that risk-averse individuals have higher expenditures on mitigation activities (Dionne and Eeckhoudt 1985; Briys and Schlesinger 1990).

Overview of State-operated Insurance Programs

Kousky (2011) provides a thorough summary of state-run insurance programs, including their origins, how they are funded and operated, pricing strategies, and means for dealing with claims during catastrophic event years. State insurance programs take a variety of forms including Fair Access to Insurance Requirements (FAIR) plans[2], wind pools, hybrid programs that write both dwelling and hazard-specific policies, and reinsurance funds which provide secondary insurance for primary insurers (Kousky 2011). Originally, most insurance plans provided protection for perils including wind (Insurance Information Institute 2013). However, insurers have canceled such coverage in areas where a high risk of hurricanes exists, and for this reason, several state governments have been pressured to intervene in the wind insurance market, creating state-run windstorm underwriters associations, also known as "wind pools" or "beach plans", offering wind coverage where private insurance is not available. As of 2008, wind pools covered more than $17 billion worth of property (Pompe and Rinehart 2008). Today, wind pools exist in Alabama, Florida, Georgia, Hawaii, Louisiana, Mississippi, North Carolina, South Carolina, and Texas (American Insurance Association 2013; Kousky 2011).

Each state program has different pricing goals. For example, Alabama Insurance Underwriting Association (AIUA) and Louisiana Citizens are legally bound to set prices above

[2] Fair Access to Insurance Requirements (FAIR) plans were established under the Housing and Urban Development Act of 1968, with the intent to provide insurance to individuals who cannot obtain it in the voluntary market. Currently, thirty two states and Washington, D.C. have FAIR Plans (Kousky 2011).

those in the private market (Alabama Insurance Underwriting Association 2013; Kousky 2011; Louisiana Citizens Property Insurance Corporation 2013). The language adopted by the Texas Windstorm Insurance Association (TWIA) is that prices must be "reasonable, adequate, and not unfairly discriminatory". Florida Citizens originally required higher prices than private market but the requirement was abandoned in 2007. Florida Citizens is now more actively competing in the private market (Kousky 2011). According to a Texas Department of Insurance survey of Gulf Coast states, average residential wind-only premiums are highest in Alabama and Mississippi (approximately $11 per $1,000 of insured value), Texas and Louisiana have average prices slightly above $5 per $1,000 of insured value, and Florida has the lowest average price (approximately $4 per $1,000 insured value) (2012). These programs offer a variety of premium discounts for homeowners that meet certain building codes and/or adopt additional mitigation measures (Alabama Insurance Underwriting Association 2013; Florida Citizens; Louisiana Citizens 2013; Mississippi Windstorm Underwriting Association 2013; Texas Windstorm Insurance Association 2013).

Survey Instrument and Data

An online survey was administered in August and September 2010, by Knowledge Networks to their Knowledge Panel®, to obtain household-level information regarding risk preferences, risk perceptions, and risk management decisions on hurricanes. The target population was property owners aged 18 or over within 96 coastal counties in Alabama, Mississippi, Texas, Louisiana, and Florida. Out of 1,536 sampled, 1,070 (69.6%) responded, and 859 consented access to their street address. Table 1 reports a demographic comparison of selected population and our sample. It shows that our sample reasonably represents the population within the 96 coastal counties.

Table 1 about here

Figure 1 presents a map of the targeted sample. Five hundred eleven respondents (62%) were from Florida, 188 (22%) were from Texas, 98 (12%) were from Louisiana, and 32 (4%) were from Alabama and Mississippi. The survey contained 41 questions and took 20 minutes to complete. Based on street address provided by respondents, we identified the distance from the shoreline to their properties.

Figure 1 about here

The wind insurance question asked respondents to indicate whether they have wind coverage included on their regular property insurance, have separate wind insurance, or do not have any wind insurance.

> *Is **wind** coverage included on your regular homeowner's policy, or do you have a separate **wind** policy?*
>
> - *Wind is included on my regular homeowner's policy.*
> - *I have a separate wind-only policy.*
> - *Wind is NOT included on my regular homeowner's policy, and I do NOT have a separate wind-only policy.*

The mitigation question asked respondents to indicate all the mitigation features they installed on their properties:

Please indicate whether your home has any of the following storm-resistant features:

Storm shutters	*Yes*	*No*	*Don't know*
Roof anchors	*Yes*	*No*	*Don't know*
Reinforced doors	*Yes*	*No*	*Don't know*
Wind-resistant glass	*Yes*	*No*	*Don't know*
Wind-resistant shingles	*Yes*	*No*	*Don't know*
Hurricane ties	*Yes*	*No*	*Don't know*
Elevated on piles	*Yes*	*No*	*Don't know*

Other storm-resistant features (please describe): ________________________________

Based on their responses, we aggregated the number of mitigation activities.[3] We treat "don't know" responses as "no" responses. We also reviewed other mitigation activities written-in by respondents, and when legitimate, included these in the total count.[4]

Tables 2 and 3 report the frequencies of responses to the wind insurance and wind mitigation questions by state. The lion's share of respondents reported having wind coverage included on their regular policy. Of those for which it is excluded, however, Alabama/ Mississippi has the highest proportion of those buying separate wind coverage (71 percent, although this proportion is based on very few observations), followed by Texas (48 percent),

[3] We excluded elevation of the property from the count of mitigation activities because this applies to flood risk rather than wind.

[4] Additional wind mitigation activities added to the total count include metal roof, hip roof, polypropylene screening, reinforced garage door, concrete blocks, and boarded windows.

Florida (26 percent), then Louisiana (17percent). Regarding mitigation activity, Florida has the highest proportion of mitigators (i.e., those reporting at least one mitigation activity) at 79 percent, followed by Alabama/Mississippi (69 percent), Louisiana (53 percent) and Texas (51 percent). Overall, the results imply a mean of just over two activities per household for Florida, just under two for Alabama/Mississippi, and just over 1 for Louisiana and Texas.

Tables 2 and 3 about here

Figure 2 presents the data in a different way, directly comparing insurance coverage and mitigation activity. Reported are the cumulative distributions of number of wind mitigation activities undertaken by wind insurance type. Over 40 percent of those with no wind coverage whatsoever, i.e., those whose regular homeowner's policy excludes wind and who chose not to buy a separate wind policy, also have undertaken no mitigation activities, whereas only 25 percent of those with a separate wind-only policy (again, because their regular homeowner's policy excludes wind peril) have undertaken no mitigation activities. As Figure 2 makes clear, these latter respondents are also more likely to undertake multiple mitigation activities. For example, half of these respondents have undertaken 3 or more mitigation activities. By contrast, almost seventy percent of those who hold no wind coverage whatsoever have undertaken at most 1 mitigation activity, and almost 90 percent have undertaken 2 or fewer. Finally, as Figure 2 illustrates, those who have wind coverage included in their regular policy fall in between these two categories. These preliminary results indicate that the decision to mitigate and the decision to insure may be positively correlated. The survey also asked respondents to indicate the main reason for not installing additional (or any) mitigation features (see Table 4). The two leading reasons for not mitigating were high up-front installation costs and the perception that further mitigation was not necessary.

Figure 2 about here

Table 4 about here

Risk preferences were measured in two ways. The first is a subjective measure that asks the respondent to assess his own tolerance for risk relative to others. Specifically, the question asked:

In general, do you consider yourself more, less, or about the same of a risk-taker than your family members, friends, and neighbors?

- *More*
- *Less*
- *About the Same*

Risk preferences were also measured using a real-money Holt and Laury (2002) experiment in which respondents were asked to make a series of choices between low-variance and high-variance risks of loss or gain. We use the total number of low-variance choices over the loss domain as an experimental measure of increasing risk aversion.[5]

Risk perceptions were measured using the following survey questions:

*Suppose a Category 3 hurricane (wind speeds of 111-130 mph) did directly strike your community. How much damage (**expressed as a percentage of total structure value**) do you think your home would most likely suffer?*

0%------------20%------------40%------50%------60%------------80%------------100%
(no damage) (moderate damage) (severe damage) (total loss)

[5] We also estimated the model using choices over the gain domain instead of over the loss domain, using both measures simultaneously, and using an aggregated measuring combining both. Results were not sensitive to these variations.

Based on your experience, how many ***major hurricanes*** *(Category 3 or greater, with winds of 111 mph or greater) do you expect to directly strike your community over the next 50 years?*

______ *Major Hurricanes (Category 3 or greater) over the next 50 years*

We measured perceptions about credibility of insurer and the likelihood of being eligible for governmental post-disaster assistance using the following questions:

If a major hurricane hit your community, how much confidence do you have that insurance companies will pay the full amount on storm damage claims?

Please rate on a scale of 1 to 5 (with 1 having no confidence and 5 having full confidence).

If a major hurricane hit your community and the federal government set up a program to provide disaster payments for home damage, how likely do you think that ***you*** *would be eligible for a program like his?*

(Indicate how likely, with 1 being very unlikely and 5 being very likely.)

We also include data on county-level federal mitigation grants, including the Flood Mitigation Assistance program since 1996, and the Repetitive Flood Claims and Severe Repetitive Loss programs since 2008. Because our survey was conducted in 2010, grants awarded through 2010 were aggregated into a single measure and then assigned to sample respondents based on county of residence. These data were obtained from the Federal Emergency Management Agency.

Other relevant data collected include housing type (house, condominium/apartment, or mobile home), mortgage contract, the number of years living in coastal areas, past wind damage experience, and other demographic factors including income, race, gender, and presence of children in the household. These data are detailed further in the model section.

Conceptual and Empirical Model

We assume that individuals make a marginal benefit/cost calculation based on the subjective expectation of utility achieved by purchasing and not purchasing wind coverage, respectively. We model the difference between these utilities as an unobserved variable y_C^* such that:

$$y_C^* = \boldsymbol{x_C}'\boldsymbol{\beta_C} + \varepsilon_C$$

where $\boldsymbol{x_C}$ is a vector of explanatory factors and $\boldsymbol{\beta_C}$ are parameters to be estimated. We assume that ε_C has mean zero and a standard normal distribution with variance normalized to one (because the sample data contain no information about the scale). We do not observe the net benefit of the purchase, only whether it is made or not. Therefore, our observation is:

$$y_C = \begin{cases} 1 \text{ if } y_C^* > 0 \\ 0 \text{ if } y_C^* \leq 0 \end{cases}$$

Next, we assume that individuals choose the number of wind mitigation activities installed that maximizes subjective expectation of utility. The survey instrument asked respondents only about particular mitigation activities, whereas in reality, some respondents may have undertaken additional mitigation activities that we do not observe. Thus, the data are censored from below by zero and from above by the maximum number of mitigation activities queried.[6] We model the unobserved utility-maximizing number of mitigation activities as:

$$y_M^* = \boldsymbol{x_M}'\boldsymbol{\beta_M} + \varepsilon_M$$

where $\boldsymbol{x}_M$ is a vector of explanatory factors and $\boldsymbol{\beta}_M$ are parameters to be estimated. We assume that ε_M has mean zero and a normal distribution with variance σ^2. However, we do not observe y_M^* directly, but rather we observe y_M, where:

$$y_M = \begin{cases} 0 \text{ if } y_M^* \leq 0 \\ y_M^* \text{ if } 0 < y_M^* < \overline{y}_M \\ \overline{y}_M \text{ if } y_M^* \geq \overline{y}_M \end{cases}$$

where $\overline{y}_M$ is the maximum number of mitigation activities queried.

The above models can be estimated independently, but because these choices are so closely related, both being responses to risk of wind damage, and likely functions of some of the same observed and unobserved factors, it is reasonable to assume correlated disturbances, such that:

$$\boldsymbol{\Sigma} = \begin{pmatrix} \varepsilon_C \\ \varepsilon_M \end{pmatrix} | \, \boldsymbol{x_C}, \boldsymbol{x}_M \sim N\left[\begin{matrix} 0 \\ 0 \end{matrix}, \begin{pmatrix} 1 & \rho \\ \rho & \sigma \end{pmatrix}\right]$$

[6] The survey did allow for respondents to write-in additional mitigation features not listed. Nevertheless, this format is still susceptible to limiting respondents' responses to those features explicitly listed.

where ρ is the covariance between ε_C and ε_M. Under the null hypothesis that ρ equals zero, the model reduces to a set of independent models. Under the alternative hypothesis that ρ is non-zero, however, full-information maximum likelihood, i.e., joint estimation, is, in general, more efficient. A generalized linear approach that allows for mixed processes for two seemingly unrelated regressions, in this case, a probit equation (for binary wind coverage) and a tobit equation (for censored wind mitigation count) can be utilized. We relied on the user-written command "cmp" in Stata (see Roodman 2011). The "cmp" routine has been used elsewhere in the literature for similar cases of mixed processes, for example, in Hottenrott and Peters (2012), Dias (2010), and Teisl and Roe (2010). The "cmp" routine is also advantageous in that models can vary by observation. In the present case, the decision to purchase wind-only coverage is limited to a subset of households in the sample for whom wind is excluded from their standard homeowner's policy, whereas the decision on mitigation extent is relevant to all households in the sample.

Starting with the likelihood for the independent probit model, which takes the form:

$$L_i(\boldsymbol{\beta_C}, \sigma_C^2; y_{Ci} \mid \boldsymbol{x_{Ci}}) = \begin{Bmatrix} \Phi(-\boldsymbol{x_{Ci}}'\boldsymbol{\beta_{Ci}}; \sigma^2) & \text{if } y_{Ci}^* = 0 \\ 1 - \Phi(-\boldsymbol{x_{Ci}}'\boldsymbol{\beta_{Ci}}; \sigma^2) & \text{if } y_{Ci}^* = 1 \end{Bmatrix} = \int_{h^{-1}(y_{Ci})} f_\varepsilon(\varepsilon) d\varepsilon$$

where $\Phi(\bullet)$ is the cumulative normal distribution and $h^{-1}(0) = (-\infty, -\boldsymbol{x_{Ci}}'\boldsymbol{\beta_{Ci}}]$ and $h^{-1}(1) = (-\boldsymbol{x_{Ci}}'\boldsymbol{\beta_{Ci}}, \infty)$, and the likelihood for the independent tobit model, which takes the form:

$$L_i(\boldsymbol{\beta}_M, \sigma_M^2, \overline{y}_M; y_{Mi} \mid \boldsymbol{x_{Mi}}) = \begin{Bmatrix} \Phi(-\boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}; \sigma_M^2) & \text{if } y_{Mi}^* \leq 0 \\ \phi(y_{Mi} - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}; \sigma_M^2) & \text{if } 0 < y_{Mi}^* < \overline{y}_M \\ 1 - \Phi(\overline{y}_M - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}; \sigma_M^2) & \text{if } y_{Mi}^* \geq \overline{y}_M \end{Bmatrix} = \int_{h^{-1}(y_{Mi})} f_\varepsilon(\varepsilon) d\varepsilon$$

where $\phi(\bullet)$ is the normal probability density and

$$h^{-1}(y_{Mi}) = \begin{cases} (-\infty, -\boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}] & \text{if } y_{Mi}^* \leq 0 \\ \{y_{Mi} - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}\} & \text{if } 0 < y_{Mi}^* < \overline{y}_M \\ [\overline{y}_M - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_{Mi}, \infty) & \text{if } y_{Mi}^* \geq \overline{y}_M \end{cases}.$$

and supposing that we observe some $\boldsymbol{y_i} = (y_{Ci}, y_{Mi})' = (0, y_{Mi})'$, where $0 < y_{Mi} < \overline{y}_M$, then, with the error structure $\boldsymbol{\Sigma}$ defined above, the joint likelihood function takes the form

$$L_i(\boldsymbol{\beta_C}, \boldsymbol{\beta}_M, \boldsymbol{\Sigma}; \boldsymbol{y}_i \mid \boldsymbol{x_i}) = \phi(y_{Mi} - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_M; \sigma)\Phi\left(-(y_{Ci} - \boldsymbol{x}_{Ci}'\boldsymbol{\beta}_C) - \frac{\rho}{\sigma}(y_{Mi} - \boldsymbol{x}_{Mi}'\boldsymbol{\beta}_M); 1 - \frac{\rho^2}{\sigma}\right)$$

(see Roodman 2011 for more details).

Table 5 reports variable descriptions, and Table 6 reports summary statistics and expected coefficient signs for the explanatory variables included in vectors $\boldsymbol{x_C}$ and $\boldsymbol{x}_M$. Both models contain measures of subjective risk and other information, including risk aversion, perceived insurer credibility, perceived likelihood of eligibility for post-disaster aid, and perceived storm frequency. The insurance equation also includes a measure of perceived conditional expected damage, which is omitted from the mitigation equation because respondents answered this question after they had already undertaken their respective wind mitigation activities, meaning that expected damage is likely a function of mitigation.

Tables 5 and 6 about here

Ideally, any model of choice for a market good should contain variables for its own price and those of close substitutes and complements. However, we do not observe what would have been the cost of insurance and mitigation for those respondents who chose not to purchase it, and mitigation costs can vary widely. Furthermore, prices for wind policies are generally set at the state level, with any price differences usually a function of mitigation activities undertaken (for discounts). Thus, insurance price differences generally reflect only differences in risk exposure. This is similar with the National Flood Insurance Program, whose rates vary according to flood zone, whether the structure was built before or after the publication of the local flood map, number of stories, structure type, and elevation above the base flood. Mitigation costs are not directly observed and can be influenced by many idiosyncratic factors. This being the case, rather than including a proximate insurance price variable that may be construed as a single measure of overall risk exposure or a cost estimate for mitigation measures, our empirical models instead contain variables that should reflect objective risk exposure (as opposed to subjective perceptions of risk exposure, which we also include), including measures of proximity to the coastline, housing type, presence of a mortgage, and state of residence (to reflect any state-specific price and/or any other political or administrative differences). This is similar to the arguments used by Petrolia, Landry, and Coble (2013) in their study of federal flood insurance.

Finally, the models also contain measures of other relevant factors, including county-level federal mitigation grant dollars, the number of years living in coastal areas, experience with past wind damage, housing type, mortgage contract, income, presence of children, gender, and race.

Results

Table 7 reports the results of the simultaneous wind coverage and wind mitigation regressions, including marginal effects for the probit regression. Note that the wind coverage model applies only to those households for whom wind coverage is excluded from the standard homeowner's policy; these respondents face the explicit choice of purchasing a separate wind policy or living with no wind coverage. The number of observations for this model is 238. The mitigation model applies to the entire sample of 829. The correlation coefficient for the error distribution is statistically significant and positive indicating that the two decisions - to purchase wind insurance and to mitigate wind risk - are related via their respective disturbance terms, confirming that the simultaneous approach is superior to independent regressions. Our results indicate that wind insurance and wind mitigation measures are positively correlated after conditioning on the covariates that have been included in our model.

Table 7 about here

Wind Insurance

Our subjective risk preference measure indicates that respondents who perceive themselves to be less of a risk taker than others are 13.5 percent more likely to purchase a wind policy relative to those who perceive themselves to be more of a risk taker. Although the coefficient for risk-neutral respondents has the expected sign, it is not statistically significant. Inconsistent with the findings of Petrolia, Landry, and Coble (2013), however, the experimental measure of risk aversion derived from the Holt and Laury (2002) mechanism was not significant. Thus, while risk-aversion over the loss domain of lotteries had predictive power in regression models of flood insurance, it does not exhibit similar validity in a similar model of wind insurance purchase.

We find no significant effect of perceived insurer credibility or perceived eligibility for post-disaster assistance on the probability of purchasing wind insurance. We find no significant effect of perceptions on expected storm frequency or conditional expected damage on the probability of purchasing separate wind coverage.

We find a significant and negative effect of county-level federal mitigation grant dollars, indicating that perhaps mitigation undertaken at the community level may act as a substitute for private wind coverage. We find that respondents who experienced past wind damage are 11.6 percent more likely to purchase wind insurance. This is consistent with the literature, which indicates that hazard event experience heightens sensitivity to risk (Baumann and Sims 1978; Kunreuther 1978; Kriesel and Landry 2004; Carbone, Hallstrom, and Smith 2006; Petrolia, Landry, and Coble 2013).

Consistent with our expectations, we find that respondents who live in the coastal zone (here defined as within three kilometers of the shoreline) are significantly more likely to hold a wind policy (specifically, 33.3 percent more likely). This result is consistent with Kriesel and Landry (2004) and Petrolia, Landry, and Coble (2013), who find a negative correlation between the likelihood of holding a flood insurance policy and the distance from the shoreline.

The coefficient on mortgage is significant and positive, indicating that those with a mortgage are more likely to carry wind coverage. Although we are unaware of any explicit state-level requirements for holding wind coverage as part of a mortgage, this may be evidence of lenders encouraging or insisting upon coverage as a prerequisite for obtaining a loan. It may also be a side-effect of the flood insurance program's requirement for flood coverage on mortgaged properties. We also find that individuals who live in a condominium are less likely to purchase a wind policy relative to individuals who live in a single family house.

Based on both the reported coefficients and post-regression tests of parameter equivalence on individual state indicators, we find that respondents living in

Alabama/Mississippi and Texas are significantly more likely to purchase wind coverage relative to those in both Florida (the base) and Louisiana. Results indicate that respondents in Louisiana are not significantly different from those in Florida.

Consistent with the findings from other studies (Baumann and Sims 1978; Browne and Hoyt 2000; Kunreuther 2006; Landry and Jahan-Parvar 2011; Petrolia, Landry, and Coble 2013), we confirm a significant positive impact of income on the probability of purchasing wind insurance. Our results indicate that one percent increase in income results in 11.1percent increase in the probability of purchasing a wind policy. Finally, we find that respondents who are female and who have children in the household are less likely to purchase a wind policy. We find no significant effects due to race.

Wind Mitigation

The wind mitigation model includes the same explanatory variables as the insurance model with exceptions of the expected damage variable being omitted and a variable indicating whether wind peril is excluded from the homeowner's regular policy being included. The excluded wind peril variable is significant, but contrary to our original hypothesis, is negative. This indicates that those for whom wind peril is excluded from the regular homeowners' policy (implying areas of high wind risk) actually undertake 0.38 fewer mitigation activities than those in lower risk areas. This result runs somewhat counter to the finding of Carson, McCullough, and Pooser (2013) who find increased mitigation activity among homes in Florida's "Wind-Borne Debris Region", as well as the theoretical predictions of Lohse, Robledo, and Schmidt (2012); what we find is that, among those in such high-risk areas, there appear to be two groups: those who mitigate more and also carry a separate wind policy, and those who mitigate less and who carry no wind coverage. But on average, we find that those in such high-risk areas tend to mitigate less.

Neither perceived nor experimental measures of risk preference have a significant effect on the decision to mitigate. We find that perceived insurer's credibility is significant, but contrary to our expectation, positive, indicating that individuals who perceived insurer to be credible undertake 0.43 more mitigation activities. The correct interpretation of this result is not clear; however, given that our results indicate that the decision to buy a wind policy is positively correlated with the decision to mitigate, then it should not be surprising that those who perceive insurers to be more credible (and thus more likely to buy insurance) are also more likely to mitigate. Consistent with the finding from the insurance model, perceived eligibility of post-disaster assistance is not significant, but county-level federal mitigation grant dollars has a negative effect on the number of mitigation activities undertaken, again implying a potential substitution effect of community-level mitigation for private mitigation. We find a positive effect of expected storm frequency on mitigation; those that perceive a shorter return period for Category 3 hurricanes are more likely to mitigate, though the effect diminishes as return period increases (implied by the negative quadratic term). Consistent with the findings of Peacock (2003), we find a positive correlation between past damage experience and mitigation activities, indicating that respondents who experienced wind damage in the past undertake 0.47 additional mitigation activities.

As hypothesized, and consistent with the findings of Peacock (2003), we find that individuals who live in the coastal zone undertake 0.63 additional mitigation activities. Also, we find that the years of living in a coastal area and the number of mitigation activities undertaken are negatively correlated. Consistent with the finding from wind insurance model, we also find that individuals who live in a condominium are less likely to mitigate wind risk relative to individuals who live in a single family house. Although we find that a mortgage contract is positively correlated with purchasing a wind policy, we find that is negatively correlated with mitigation activities indicating that those who have a mortgage contract tend to undertake 0.34 fewer mitigation activities. Also, we find that the level of mitigation is lower in all states relative to Florida: Alabama/Mississippi residents undertake 0.7 fewer units, Louisiana residents undertake 1.4 fewer units, and Texas residents undertake 1.5 fewer units relative to Florida residents.

Consistent with the findings of Carson, McCullough, and Pooser (2013) and Peacock (2003), we find a positive income effect on mitigation activities. Our results indicate that individuals tend to undertake 0.25 more mitigation activities as their income level increases by one percent. We also find that white respondents undertake fewer mitigation activities relative to minorities. Finally, we find no significant effect of the presence of children in the home. This result runs contrary to the findings of Carson, McCullough, and Pooser (2013). They find a greater probability of mitigating in the presence of children, but their measure was at the community level: the proportion of the population in the home's zip code under the age of eighteen.[7] Given that ours is a direct measure of the presence of children in each home, ours may represent a more accurate account of this effect. Finally, we find that non-white and male respondents tend to mitigate more than white and female respondents.

[7] However, they find no significant effect of children on extent of mitigation.

Summary and Conclusions

We present the results of what we believe to be the only household-level analysis of the decision to purchase a wind-only policy when wind peril is excluded from the homeowner's regular policy, and one of very few analyses of the extent of mitigation activities specific to wind risk. We believe this to be the only study that models these two closely-related behaviors jointly, so as to explore the conditional correlation of these activities and achieve more efficient estimation. One of the major findings is that the decision to buy a wind-only policy and the decision to mitigate are positively correlated; i.e., those that choose to insure against wind damage are also more likely to mitigate wind damage (after conditioning on covariates). We also find that among those respondents that live in areas where wind peril is excluded from the regular policy, which is generally an indication of very high wind risk, there is actually less mitigation activity, not more. Within this group, however, we find that those that choose to buy a wind-only policy also undertake a larger number of mitigation activities, whereas those that carry no wind coverage whatsoever undertake the smallest number of mitigation activities, even fewer than those who live in lower-risk areas where wind peril is included in their regular homeowner's policy.

We find that the leading reasons for not undertaking further (or any) mitigation are affordability and the belief that the homeowner's property does not need any additional mitigation. These results lend credence to the recommendation of Kunreuther, Pauly, and McMorrow (2013) that mitigation can be encouraged by addressing the affordability issue; specifically, by tying mitigation and insurance purchase to the home's mortgage and allowing for payment over time to avoid the cash-flow problem associated with high upfront costs for mitigation. The issue of affordability may also be reflected in our finding that income is positively correlated with the extent of mitigation. As for the perception of benefits, states may wish to better inform homeowners of the mitigation options available and how these activities can reduce the probability and extent of damage in the event of a storm. Additional research on cost-effective mitigation measures that can be easily related to homeowners appears warranted.

Regarding perceptions of insurer credibility, we find no direct impact on the likelihood of holding optional wind coverage, but we find a positive effect on wind mitigation activities. Expectations of disaster assistance, however, do not appear to significantly affect the decision to buy a wind policy or to mitigate. On the other hand, we find that county-level federal mitigation grant dollars has a negative effect on both purchasing wind coverage and undertaking mitigation activities, indicating that there may be some degree of substitution of community-level risk management for private risk management.

We find that wind-only policy uptake rates are substantially higher in Texas and Alabama/Mississippi, compared to Florida and Louisiana. On the other hand, we find that extent of mitigation activities are higher in Florida and Alabama/Mississippi relative to Louisiana and Texas. Thus, our results suggest that Alabamans, Mississippians, and Texans tend to favor insurance over mitigation as a means to protect against wind, Floridians tend to favor mitigation over insurance, and Louisianans tend to do less of both, relative to their neighbors. That Floridians tend to purchase less insurance relative to their neighbors is somewhat surprising, given that Florida's wind insurance program is the only one of the five Gulf states that directly competes in the private market, i.e., should tend to have relatively lower premiums relative to the other states whose programs are explicitly markets of "last resort" (Kousky 2011) . In fact, a recent survey found that the average premium per $1,000 of coverage was less than $4 in Florida, over $5 in Louisiana and Texas, and over $10 in Alabama and Mississippi (Texas

Department of Insurance 2012). Given that we find the relative take-up rate in Florida to be the lowest, there must be other factors besides price that explain differences across states that our model does not capture.

Consistent with the findings of Petrolia, Landry, and Coble (2013), we find that risk-averse respondents are significantly more likely to buy wind insurance; however, risk aversion had no effect in our mitigation model, suggesting, perhaps, that subjective measures of risk preferences could be more relevant for insurance decisions, but that mitigation decisions are dominated by other factors. Experimentally-derived measures of risk aversion (Holt and Laury 2002) exhibited no correlation with wind insurance purchase or mitigation, in stark contrast to the finding by Petrolia, Landry, and Coble (2013) on flood insurance. Also we do not find a significant impact of conditional expected damage on either wind coverage or mitigation. We do find, however, an effect of expected storm frequency on mitigation. Our results indicate that the perceived expectation of storm frequency is positively correlated with the number of mitigation activities, but that the relationship becomes negative at higher perceived storm frequencies.

Also, consistent with previous literature which indicates that hazard event experience heightens sensitivity to risk (Baumann and Sims 1978; Kunreuther 1978; Kriesel and Landry 2004; Carbone, Hallstrom, and Smith 2006; Petrolia, Landry, and Coble 2013), we find that actual past experience with wind damage is significant in explaining both the decision to buy a wind policy and the extent of mitigation. Finally, consistent with previous literature, we find a positive income effect on purchasing insurance (Baumann and Sims 1978; Browne and Hoyt 2000; Kunreuther 2006; Landry and Jahan-Parvar 2011; Petrolia, Landry, and Coble 2013) and on mitigation (Carson, McCullough, and Pooser 2013; Peacock 2003).

Finally, we wish to make a few comments regarding the way forward. Given the divergence in types of coverage, types and levels of government efforts to encourage mitigation and coverage, and the types of incentives to undertake them, future research should focus on better understanding how individuals receive and process the myriad of information and options available to address coastal wind as well as flood risk, and how to reduce the transactions costs associated with obtaining coverage and undertaking mitigation for both. There have been several proposals made in favor of merging flood and wind peril into a single (or all-perils) policy (see Brown 2010; Pidot 2007; Pompe and Rinehart 2008; and U.S. GAO 2008), as well as proposals to couple insurance contracts with multiyear home-improvement loans to encourage mitigation (Michel-Kerjan and Kunreuther 2011). Future research should focus on understanding how and the extent to which consumers would respond to such alternatives, and whether such approaches would simplify the process for consumers and encourage mitigation as well as participation in insurance programs.

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Table 1

Comparison of population and sample demographics, all shown as percentage of total (N=829)

	Population	Sample
Age		
18-44	0.29	0.21
45-59	0.31	0.36
60+	0.40	0.43
Gender (% Male)	0.47	0.45
Race		
Black	0.09	0.05
Hispanic	0.13	0.10
White	0.74	0.82
Other	0.04	0.03
Education		
High school or below	0.39	0.23
Some college	0.27	0.31
Bachelor's or above	0.34	0.46
State of residence		
Alabama / Mississippi	0.04	0.04
Florida	0.64	0.62
Louisiana	0.14	0.12
Texas	0.18	0.23
Metro resident	0.94	0.95
Internet access	0.72	0.95

Table 2

Frequency of respondents by wind insurance type, by state

Wind Insurance Type	Alabama / Mississippi	Florida	Louisiana	Texas
Wind included on regular policy	25	367	81	117
Wind excluded on regular policy	7	144	17	71
% with separate wind coverage	(71.4)	(26.4)	(17.7)	(47.9)
% with no wind coverage	(28.6)	(73.6)	(82.4)	(52.1)
Total	32	511	98	188

Table 3

Frequency of respondents by number of wind mitigation activities, by state

Number of Mitigation Activities Undertaken	Alabama / Mississippi	Florida	Louisiana	Texas
0	10 (0.31)	106 (0.21)	46 (0.47)	92 (0.49)
1	7 (0.22)	91 (0.18)	21 (0.21)	42 (0.22)
2	4 (0.13)	104 (0.20)	13 (0.13)	23 (0.12)
3	5 (0.16)	83 (0.16)	9 (0.09)	15 (0.08)
4	2 (0.06)	71 (0.14)	4 (0.04)	9 (0.05)
5+	4 (0.13)	56 (0.11)	5 (0.05)	7 (0.04)
Total	32	511	98	188
Mean	1.81	2.20	1.18	1.11

Note: Proportions are in parentheses.

Table 4

Survey Question: For storm-resistant features that your home does NOT have, what is the main reason that you have not installed them?

	Freq.	(Prop.)
I am unsure of the level of protection they would provide.	72	(0.09)
The insurance benefits (discounts) don't outweigh the installation costs.	59	(0.07)
The up-front installation costs are too high.	277	(0.34)
I do not think that my home needs any additional storm-resistant features.	359	(0.44)
Other	53	(0.06)
Refused	3	(0.003)
Total	829	(1.00)

Table 5

Descriptions of Variables

Variable Name	Type	Description
Wind Policy	Binary	Dependent variable, =1 if purchased separate wind insurance, =0 if did not have wind insurance
Wind Mitigation	Count	Dependent variable, the number of wind mitigations installed ranged from 0 to 7
Wind Excluded	Binary	=1 if wind coverage is excluded from regular property policy, =0 otherwise
Risk Averse (Experimental)	Continuous	Number of instances where low-variance risk was chosen over loss domain; ranges from 0 (risk loving) to 5 (risk averse)
Risk Averse (Perceived)	Binary	=1 if consider themselves less of a risk-taker than their family members, friends, and neighbors, =0 otherwise; excluded category is 'more of a risk-taker than others'
Risk Neutral (Perceived)	Binary	=1 if consider themselves about the same a risk-taker as their family members, friends, and neighbors, =0 otherwise; excluded category is 'more of a risk-taker than others'
Credibility	Binary	=1 if perceived confidence that insurer will pay full amount of claims in event of a major hurricane is ranged between 3 and 5 (1 being "no confidence", 5 being "full confidence"), =0 otherwise;
Eligibility	Binary	=1 if perceived likelihood of eligibility for governmental aids after a major hurricane is ranged between 3 and 5 (1 being "very unlikely", 5 being "very likely"), =0 otherwise
Grants	Continuous	Aggregated county level federal mitigation grants from 1996 to 2010; scaled down by $100,000
Expected Damage	Ordered Categorical	Expected damage (as a percentage of total structure value) from a major hurricane (category 3), ranges from 0% (0.0) to 100% (1.0) by 10% (0.1)
Expected Frequency	Continuous	Expected number of future hurricanes (category 3 or greater) over next 50 years
Expected Frequency Squared	Continuous	The squared number of expected future hurricanes (category 3 or greater) over next 50 years; scaled down by 100
Wind Damage	Binary	=1 if had wind damage in the past, =0 otherwise
Coastal Zone	Binary	=1 if distance to closest shoreline is within 3km, =0 otherwise

Table 5 Continued

Coastal Years	Continuous	The number of years living on the Gulf or Atlantic coast
Condo	Binary	=1 if housing type is condominium or apartment, =0 otherwise; single family residents is the excluded category
Mobile Home	Binary	=1 if housing type is mobile home, =0 otherwise; single family residents is the excluded category
Mortgage	Binary	=1 if home is mortgaged, =0 otherwise
Alabama/Miss	Binary	=1 if lived in Mississippi or Alabama, =0 otherwise
Louisiana	Binary	=1 if lived in Louisiana, =0 otherwise
Texas	Binary	=1 if lived in Texas, =0 otherwise
Ln(Income)	Continuous	= Natural log of income (category ranges from “less than $5,000” to “$175,000 or more”; mid-point of each category assigned in dollars)
Kids	Binary	=1 if have kids, =0 otherwise
White	Binary	=1 if white, =0 otherwise
Male	Binary	=1 if male, =0 otherwise

Table 6

Summary Statistics

Variable Name	Insurance Model N=238 Mean	Std. Dev.	Min.	Max.	Mitigation Model N=829 Mean	Std. Dev.	Min.	Max.	Exp. Sign
Wind Policy	0.34	.	0	1					
Wind Mitigation					1.82	1.70	0	7	
Wind Excluded					0.29	.	0	1	+
Risk Averse (Experimental)	2.98	1.42	0	5	2.92	1.36	0	5	+
Risk Averse (Perceived)	0.25	.	0	1	0.29	.	0	1	+
Risk Neutral (Perceived)	0.52	.	0	1	0.54	.	0	1	+
Credibility	0.53	.	0	1	0.67	.	0	1	+/-*
Eligibility	0.59	.	0	1	0.59	.	0	1	-
Grants	28.69	79.35	0	440	37.55	95.31	0	541	+/-
Expected Damage	0.36	0.25	0	1					+
Expected Frequency	8.46	14.37	0	90	6.95	10.54	0	90	+
Expected Frequency Squared $(100)^{-1}$					1.59	6.23	0	81	+/-
Wind Damage	0.24	.	0	1	0.32	.	0	1	+
Coastal Zone	0.30	.	0	1	0.25	.	0	1	+
Coastal Years	27.03	18.59	0	76	28.30	18.52	0	80	+/-
Condo	0.13	.	0	1	0.11	.	0	1	+/-
Mobile home	0.06	.	0	1	0.05	.	0	1	+-
Mortgage	0.61	.	0	1	0.64	.	0	1	+/-
Alabama/Miss	0.03	.	0	1	0.04	.	0	1	+/-
Louisiana	0.07	.	0	1	0.12	.	0	1	+/-
Texas	0.30	.	0	1	0.23	.	0	1	+/-
Log Income	10.77	0.96	7.82	12.21	10.93	0.78	7.82	12.21	+
Kids	0.30	.	0	1	0.26	.	0	1	+/-
White	0.76	.	0	1	0.82	.	0	1	+/-
Male	0.42	.	0	1	0.45	.	0	1	+/-

Note: Expected sign of "Credibility" is positive for "Insurance Model" and positive or negative for "Mitigation model".

Table 7

Results of simultaneous probit (insurance) and tobit (mitigation) regressions

	Insurance N=238				Mitigation N=829		
	Coef.		Std. Err.	Marg. Eff.	Coef.		Std. Err.
Wind Excluded					-0.378	**	0.179
Risk Averse (Experimental)	0.092		0.075	0.023	-0.006		0.057
Risk Averse (Perceived)	0.530	*	0.308	0.135	-0.012		0.233
Risk Neutral (Perceived)	0.363		0.265	0.093	-0.048		0.212
Credibility	0.181		0.216	0.046	0.425	**	0.171
Eligibility	-0.208		0.215	-0.053	0.068		0.163
Grants	-0.003	**	0.002	-0.001	-0.002	**	0.001
Expected Damage	0.171		0.428	0.044			
Expected Frequency	-0.005		0.008	-0.001	0.038	**	0.017
Expected Frequency Squared				0.000	-0.058	*	0.030
Wind Damage	0.453	*	0.242	0.116	0.473	***	0.171
Coastal Zone	1.303	***	0.236	0.333	0.631	***	0.180
Coastal Years	-0.008		0.006	-0.002	-0.011	**	0.004
Condo	-0.751	*	0.402	-0.192	-0.507	*	0.260
Mobile home	-0.217		0.683	-0.055	0.011		0.363
Mortgage	0.549	**	0.236	0.140	-0.342	**	0.169
Alabama/Miss	1.398	**	0.596	0.357	-0.690	*	0.402
Louisiana	-0.216		0.459	-0.055	-1.380	***	0.269
Texas	0.868	***	0.234	0.222	-1.468	***	0.205
Ln(Income)	0.435	***	0.136	0.111	0.248	**	0.108
Kids	-0.507	**	0.249	-0.129	-0.252		0.187
White	0.272		0.252	0.069	-0.432	**	0.204
Male	0.401	*	0.212	0.102	0.410	**	0.159
Constant	-6.845	***	1.626		-0.551		1.253
Sigma					2.078	***	0.066
Rho	0.457		0.086				
Log Likelihood			-1546.630				

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels.

Figure 1

Map of Sample Respondents

Source: Courtesy of John Cartwright, Geosystems Research Institute, Mississippi State University.

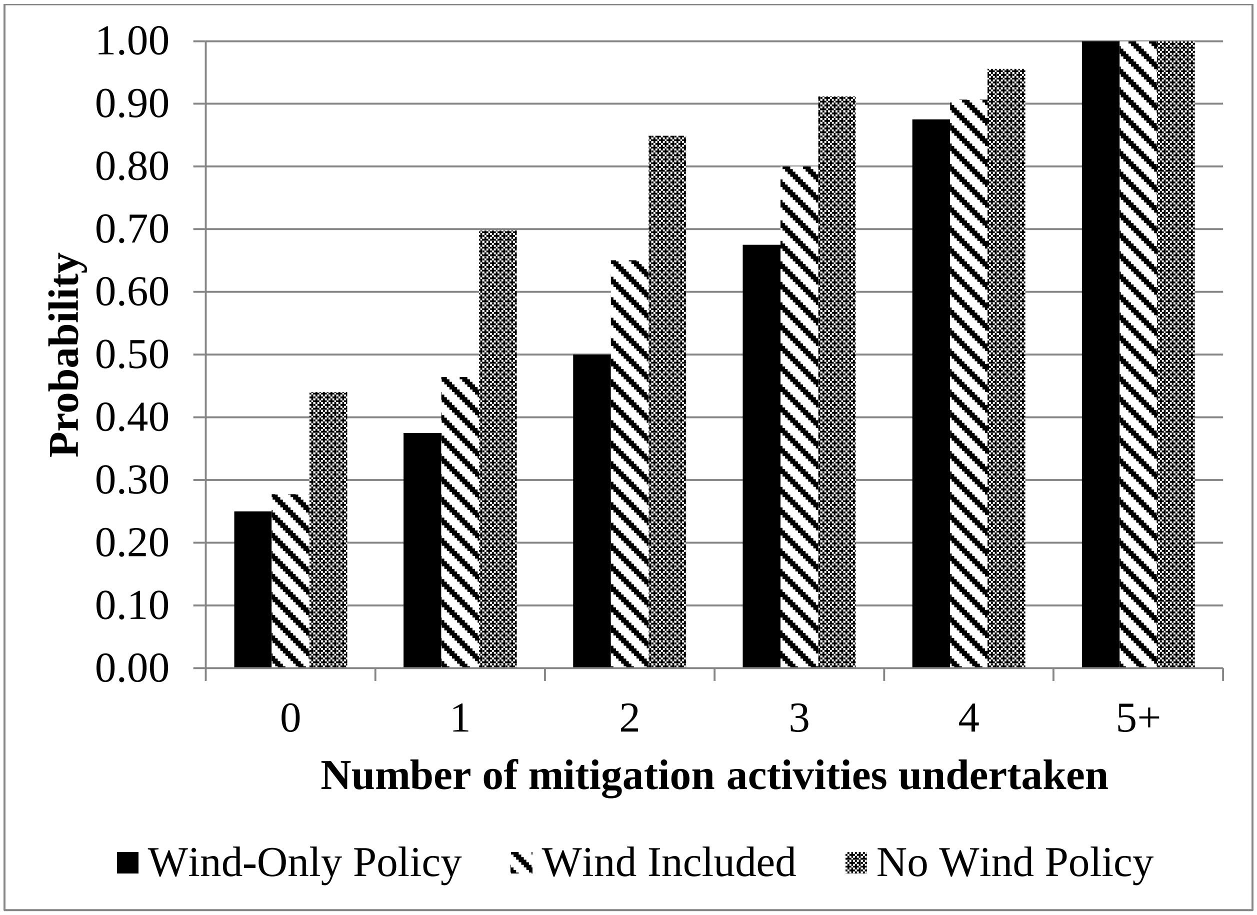

Figure 2

Cumulative distribution of number of mitigation activities undertaken by wind policy type