A sequential model to link contextual risk, perception and public support for flood adaptation policy

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Abstract

The economic damage from coastal flooding has dramatically increased over the past several decades, owing to rapid development in shoreline areas and possible effects of climate change. To respond to these trends, it is imperative for policy makers to understand individuals' support for flood adaptation policy. Using original survey data for all coastal counties of the United States Gulf Coast merged with contextual data on flood risk, this study investigates coastal residents' support for two adaptation policy measures: incentives for relocation and funding for educational programs on emergency planning and evacuation. Specifically, this study explores the interactive relationships among contextual flood risks, perceived flood risks and policy support for flood adaptation, with the effects of social-demographic variables being controlled. Age, gender, race and partisanship are found to significantly affect individuals' policy support for both adaptation measures. The contextual flooding risks, indicated by distance from the coast, maximum wind speed and peak height of storm surge associated with the last hurricane landfall, and percentage of high-risk flood zone per county, are shown to impact one's perceptions of risk, which in turn influence one's support for both policy measures. The key finding –risk perception mediates the impact of contextual risk conditions on public support for flood management policies – highlights the need to ensure that the public is well informed by the latest scientific, engineering and economic knowledge. To achieve this, more information on current and future flood risks and options available for mitigation as well as risk communication tools are needed.

Key Words: Policy support; flood adaptation; risk perception; contextual flood risk factors

1. Introduction

Coastal flooding events pose enormous risks to human lives and have caused substantial property damages (Hatzikyriakou et al., 2015; Xian et al., 2015; Nadal et al., 2009; Perry, 2000; Aerts et al. 2013). With rising damages caused by coastal flooding, there is an increasing need for risk reduction, informed development, and other adaptation and mitigation actions (Michel-Kerjan, 2015; Michel-Kerjan et al., 2015; Michel-Kerjan & Kousky, 2010; Kunreuther and Michel-Kerjan 2009). Rising sea levels and increasing storm activity in a changing climate are expected to result in more frequent and intensive flood events and therefore lead to greater damages in the future (Nicholls and Cazenave, 2010; Emanuel, 2013; Lin et al., 2016; Lin and Emanuel 2016; Lin and Shullman, 2017). In addition, there has been a dramatic increase in exposure to risks due to rapid population migration, growth and related development in coastal areas. In the United States, more than half of the population currently resides in coastal areas with large concentrations of assets near the water (Moser et al., 2014). NOAA estimates that the coastal population growth and near-shore development are likely to continue, suggesting that even more people will live under flood threats in decades to come (NOAA 2013).

Being exposed to a high level of flood risks, a variety of adaptive measures such as home elevation, flood-proofing, and construction of seal walls and barriers can be considered (Xian et al., 2017; Aerts et al. 2014; Bogardi and Warner 2009; Klima et al 2011). For those who have witnessed repetitive losses from flood events in the past, relocation to less flood prone areas may also be considered (Kick et al., 2011). In addition, flood warning for early evacuation is crucial to protect human lives (Carsell et al. 2004). It is sensible for people who are exposed to flood risks to undertake measures to mitigate future flood damages. Likewise, long-term education and investment in flood evacuation and emergency planning can raise community resilience by better ensuring the safety of people in flood-prone areas when floods do occur.

Although flood risk adaptation measures are among the most effective ways to protect people from flood threats, few people take such measures voluntarily (Baan and Klijn 2004; Bubeck et al 2012). Voluntary relocation from hazard-prone locations is unlikely to be a widely adopted option for various reasons, including family commitment, livelihood opportunities, financial constraints and emotional attachment (King et al. 2014). Likewise, some will choose not to evacuate even during extreme events (Baker, 1991; Dow and Cutter, 2000; DeYoung et al. 2016; Weller et al. 2016). Previous literature found that people's perceptions of flood risks have direct effects on their hazard mitigation incentives and evacuation behaviors (Huang et al. 2012; Ge et al., 2011). Lindell and Hwang (2008) found a mediating role of perceived risk between hazard experience and hazard adjustment behavior. Past experience with storms and evacuation have also been found to influence individual risk perception and further affect flood hazard adjustment behaviors (Ge et al., 2011; Dash 2000; Dash 2002; Whitehead et al. 2000). People tend to show less concern about flooding risks if they have not experienced an intensive flood event in the recent past. This can be explained by the "crisis effect," which refers to the observation that disaster awareness peaks immediately after events occur but rapidly dissipates thereafter (Stefanovic 2003; Atreya et al. 2013; Gallagher 2014). The previous findings highlight the necessity for policy makers to design policies that can motivate people, especially those without past experience, to take flood mitigation measures.

To make any policy effective, involving the public is a crucial step. However, there is limited literature investigating the factors that may influence individuals' policy support for flood hazard adjustment measures. The influences of social-demographic factors are potentially important and dictate the need for a large data sample. Aspects of the surrounding environment, consisting of both social and physical contexts, have a significant impact on individuals' behaviors (Stern, 2000; Zahran et al., 2006; Shao et al., 2017b). For example, the vulnerability to and experience of flooding in one's residence may heighten risk perceptions and correspondingly lead to a proactive response. But whether this would hold in policy support for coastal flood hazard adjustment needs to be explored. Moreover, the role that perceptions of flood-related risks play between contextual environment risks and policy support needs to be investigated.

Our study is one of the first systematic examinations of the relationship between socio-demographic characteristics, individuals' perceived flood-related risks, and contextual measures of flood-related risks on the one hand, and policy support for flood hazard adjustment measures on the other. Specifically, our study is the first to examine whether contextual flood-related risk would influence individuals' policy support for relocation and education on emergency planning and evacuation directly or indirectly through risk perceptions. Based on a large surveyed sample for the entire U.S. Gulf Coast, the results can help policy makers better understand public support for long-term flood hazard adjustment policies and design more effective policies to motivate coastal residents to participate in long-term programs for flood risk adaptation.

This paper is organized as follows. In the next section, the conceptual framework is laid out and key components and hypotheses are discussed. The research design, data and methods are presented in the following section. Results of the analyses are discussed subsequently. The paper concludes with a summary of findings, discussion of implications, and a path forward for future studies.

2. Conceptual Framework: Contextual Risks and Perceived Risks

Our conceptual framework consists of three components: contextual risks indicative of local physical hazards, perceived risks, and support for policies to adapt to flooding and hurricane risks. Figure 1 displays alternative hypothesized relationships among the three key components. These alternative paths are explored and drawn upon from the literature. In the Protective Active Decision Model (PADM), Lindell and Perry (2012) lay out a theoretical framework explaining factors influencing adoption of protective actions. In their framework, the environmental context constitutes the initial stage of a decision process. It provides cues which have the potential to trigger perceptions of environmental threats. A growing body of empirical studies have found a link between the environmental context and perceptions. For instance, risk perceptions of climate change are found to be positively correlated with recent temperature trends (Hamilton and Keim, 2009; Howe et al., 2013; Shao et al., 2016; Shao et al., 2014). Temperature anomalies lead to a perception of climate warming (McCright et al. 2014； Zaval et al. 2014). The objective characteristics associated with the last hurricane landfall have positive effects on individuals' perceptions of changing hurricane strength (Shao et al., 2017a). Perceptions of extreme weather events are shaped by objective impacts of these events (Cutler 2015).

In the context of the present study, the contextual flood and hurricane risk factors may have direct impacts on perceptions of flood-related risks. Risk perceptions are broadly studied in examining mitigation and adaptation behaviors, mainly driven by the "motivational hypothesis", referring to the inclination to undertake precautionary measures when perceiving high risks (Weinstein et al. 1998). It has been long speculated that perceptions of risks can directly translate into actions to reduce risks. Evidence for this link is nevertheless mixed. For instance, previous research has identified a positive relationship between risk perceptions and long-term hazard adaptation (Huang et al., 2016), while a few have found no such correlations (Lindell and Whitney, 2000; Perry and Lindell, 2008). Also, some studies show no observable relationship between risk perception and flood insurance purchase (Bauman and Sims, 1978; Laska, 1990; Lo, 2013), whereas other studies have made the observation that flooding risk perceptions lead to flood insurance purchase behaviors (Petrolia et al., 2013; Shao et al., 2017b).

In this study we consider and compare the two alternative paths shown in Figure 1 for the manner in which the presence of flood-related risks affect adaptation policy support. Drawing upon the literature (Preacher 2015), we propose a conceptual framework that allows a simple mediation analysis. Path 1 of the conceptual framework is that perceptions of flood-related risk play a mediating role, linking contextual flood-related risk and the resulting level of support for adaptation policies. Path 2 is that the contextual risks can affect individuals' adaptation policy support directly without risk perception as the mediator. In other words, the impact of contextual risks can reach policy support through alternative paths, other than risk perception. That could occur when individuals' policy support or behavior is influenced by other factors that correspond to contextual risks. For instance, the local government may incorporate local contextual risk factors into policies, such as land use restrictions and shoreline setback requirements – with residents supporting these policies because they promote better beach access and slower development – even if residents do not recognize that avoiding flood damage is the primary motivation for the policy. Similarly, contextual flood-related risks may influence other factors such as perception of social norms that directly influence the policy support or behavior (Lo, 2013). To illustrate, if one's immediate family members or close friends support one particular policy, he/she may be more likely to support it because this person deems such support as socially acceptable. These other factors are not directly measured in the survey on which the present study is based. Their influences may nevertheless reach individuals' consciousness and further intervene in their decisions through various routes. Previous empirical studies also demonstrate statistically significant impacts of contextual factors on policy support and behaviors. For example, Zahran et al. (2006) found that objective risk measures including temperature trend and frequencies of natural calamity and extreme weather events do affect climate policy support. Shao et al. (2017b) found that higher flood risks estimated by FEMA can drive individuals to voluntarily purchase flood insurance. Therefore, we consider the alternative hypothesis that contextual flood risks may be associated with support for policies that address flood risks without risk perception as the mediator.

3. Data and Methods

3.1.Research Design

The hypothesized relationships portrayed in Fig. 1 are tested using results from a recent survey of coastal residents along the U.S. Gulf Coast controlling for the effects of social-demographic factors. The questions in the study explore whether contextual flood risk is related to perceived flood-related risk, and whether these aforementioned two variables are related to policy support for relocation programs and more funding for evacuation and emergency planning. In addition to testing the hypothesized framework, we identify a preferred model by comparing the complexity-adjusted goodness of fit of the alternatives.

3.2. Survey and Contextual Risk Measurements

The survey data are extracted from the 2012 Gulf Coast Climate Change Survey which includes items related to coastal residents' perceptions of local climate risk and their willingness to take actions to adapt to climate impacts (Goidel et al. 2012). This survey provides the most comprehensive assessment to date of perceptions of climate risks and policy support to address implications of climate change in the Gulf Coast (Goidel et al. 2012). Stratified random sampling was used to draw an adequate independent sample across and within the Gulf Coast states (Florida, Alabama, Mississippi, Louisiana, and Texas). Data were collected by landline telephone calls (more than 20,000 calls) from January 3 through April 4, 2012. The response rate for the survey is 17.6 percent. The number of respondents is 3856. The survey items related to the working hypotheses in the conceptual framework involve policy support for adaptations and perceptions of flood-related risks.

The variables of interest for policy support are derived from two survey questions: 1. "Support/Oppose Incentives to Relocate from Threatened Areas?" 2. "Support/Oppose increasing funding for education on emergency planning and evacuation?" The response "oppose" is coded as -1 and "support" as 1. "Don't know" is coded as 0. In this context the question provides two clear alternatives, anyone's decision to respond "don't know" can be interpreted as being indecisive between these two options.

Perceived change in flood-related risk is gauged by two questions: 1 "would you say that the hurricanes that do impact your local community are stronger, not as strong, or about as strong as hurricanes in the past?" 2. "would you say the amount of flooding has changed?" The responses are coded on a three-point scale as −1 ("not as strong" or "decrease"), 0 ("the same"), and 1 ("stronger" or "increase"). "Don't know" is recoded as missing.

Contextual flood-related risk factors include the maximum wind speed and peak storm surge height from the last landfall hurricane and the percentage of coastal high risk flood zone, all at the county level, and distance from the coast at the household level. Hurricanes can cause both wind (e.g. Hurricane Andrew in 1992) and water damage (e.g. Hurricane Katrina in 2005). Maximum wind speed and peak storm surge from landfall hurricanes are thus related to hurricane risks. Peak storm surge height and the percentage of high risk flood zone in an area are associated with coastal flooding hazards. Percentage of high risk flood zone indicates the approximate proportion of the exposure within a county under high risk of coastal flooding. Distance from the coast can indicate the vulnerability of the household to both hurricane and flood hazards. Therefore, physical characteristics of hurricane landfalls such as maximum wind speed and peak storm surge, and proximity to the coast reflected in the distance from the coast could all influence an individual's risk perception related to hurricanes. Peak storm surge, percentage of high risk flood zone and distance from the coast could influence risk perception on flooding amount.

In this study, maximum wind speed is estimated as the final 6-h wind magnitude of the storm prior to landfall from the HURDAT Best Track data (Landsea et al., 2004). Peak storm surge height, measured at the tidal gauge/high watermark from the latest hurricane landfall, comes from the SURGEDATA, a global storm surge measurement dataset (Needham and Keim, 2012; Needham et al., 2015). The percentage of coastal area in a high risk flood zone is defined as the ratio of the area of the floodplain VE[1] zone of a county to the total area of the county and is calculated from FEMA's flood insurance rate maps (FIRMs). Distance to the coast is based on the respondents' selection from seven distance classes, ranging from adjacent/on the water to more than 60 miles.

When testing the hypotheses proposed in the framework, we control the social-demographic background variables including age, gender, race, education, and income, which have been considered in previous studies on hurricane and flood risk perception (Shao et al., 2017a; Botzen et al., 2009) and adaptation behavior (Lindell and Hwang, 2008) In addition, party identity, which was found to be important in climate risk perception and adaptation (McGright and Dunlap, 2011b; Botzen et al., 2016), is also included in our models. A summary of the statistics of the individual-level variables is shown in Table 1. The correlation among the individual-level variables is examined in Table 2 to provide insight on possible collinearity between explanatory variables and an initial identification of variables that influence perceived risks. As indicated, the correlations are generally low in magnitude, though a number of the correlation coefficients statistically differ from zero (in part due to the large sample size). Only Party ID and Race (correlation coefficient = 0.38) and Education and Income (correlation coefficient = 0.47) exhibit absolute correlation coefficients exceeding or near 0.4.

3.3. Statistical Analysis Methods

[1] VE zone refers to the floodplains that are subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm-induced wave action. The VE zone indicates the location of an overall coastal flood hazard.

The dependent variables y are categorical and ordinal (-1, 0 and 1), so that Ordinary Least Squares (OLS) models are inappropriate. Fitted models can yield predictions outside the range of the dependent variables and heteroskedasticity often results. A more appropriate method is the ordered-logit regression. The ordered logit regression equation is written as follows:

$$\log \frac{p(y \leq j)}{1-p(y \leq j)} = \log(\theta) = \beta_{0,j} + x'\beta_j \qquad \text{j=-1, 0} \qquad \text{(Eq. 1)}$$

where $p(y \leq j)$ is the probability that the dependent variable y is below j (j = -1 or 0). . The left hand of this equation is called log odds ratio (odds= θ); $\beta_{0,j}$ is the offset term and β_j is a vector of regression coefficients; x' is a vector of independent variables.

The 2012 Gulf Coast Climate Change survey database provides county FIPS codes, enabling us to merge the individual-level data with contextual data for model fitting. Merging individual-level and contextual data raises certain statistical complications, i.e. the error term of individual observations nested within the same county are no longer independent. To account for the clustered data structure of the present study, multilevel regression analyses are applied. We have two layers in our regression model. The first layer of the model targets at the individual respondent level (i.e., social-demographic variables) and its slopes ($\boldsymbol{\beta}$) are fixed (fixed effect). The second layer is for county level contextual variables (i.e., risk factor). The dependent variable of the second layer is the intercept for the first layer of the model, making the intercept random (random effect). Thus, the multilevel model here is also called an ordered-logit mixed effects model (*meologit* in Stata is used).

Applying the multilevel regression analysis and controlling social-demographic background variables, we test the following hypotheses based on the conceptual framework:

H1. Contextual flood-related risk factors are directly related to perceived flood-related risks

H2. Perceived flood-related risks are directly related to policy support

H3. Contextual flood-related risk factors are directly related to policy support

If H1 and H2 hold but H3 does not, the effects of contextual flood-related risks on policy support would be completely mediated by risk perceptions of flooding risks. If H1, H2 and H3 all hold, the effects of contextual flood-related risks on policy support are partially mediated by risk perceptions of flooding risks.

To account for differences in model complexity, we compare the models related to adaptation policy support (H2 and H3) using the Akaike information criterion (AIC). Given that there is a small difference in the number of observations in the models, we apply an adjusted form of the AIC, following the approach of Hilbe (2011):

$$AIC = \frac{-2L+2k}{n} \qquad \text{(Eq. 2)}$$

where L is the model log-likelihood; k is the number of predictors, including intercepts and n is the number of observations.

We then present predictive models that includes social-demographic background variables, risk perception and contextual risk variables.

4. Results and Discussion

4.1 Effects of Socio-demographic Background on Adaptation Policy Support

Some consistent patterns arise among social-demographic background variables (details in Table A in Supplementary Materials (S.M.). Age, gender, race, and partisanship are found to significantly affect respondents' policy support for both relocation and increased funding towards education for emergency planning and evacuation. Specifically, younger people, females, racial minorities, and Democrats are more likely than others to support the two policies.

One possible explanation for the effect of age is from previous findings that younger people are more concerned about climate-related risks (e.g. intensified hurricanes and flooding) and their consequences (Borick & Rabe, 2010; Hamilton & Stampone, 2013; Shao et al., 2017a). Another possible explanation is that young individuals are more mobile compared to older people. Both relocation and emergency evacuation require a certain amount of mobility. A previous study found that migration rate peaks for the age group from 18 to 34 and steadily declines with increasing age (Benetsky et al., 2015).

Previous studies found that white people and males tend to judge environmental risks at a lower level than non-whites and females (Finucane et al., 2000; Marshall, 2004; McCright & Dunlap, 2011a, 2011b). The racial difference is attributed to the fact that racial minorities are often especially subject to the consequences of environmental distress (Mohai & Bryant, 1998; Pais et al. 2013). The gender gap is argued to be due to different societal roles (Davidson & Freudenburg, 1996). The interpretation of results about race and gender in this study is that racial minorities and females may tend to perceive higher risks in the coastal setting, exhibit higher social norms (Lo, 2013), and express a higher level of concern, and therefore they are more likely than their counterparts to support policies to mitigate the negative impacts of these risks.

Republicans are less likely than Democrats to support the two adaptation policies. This could be attributed to their aversion to government action that constrains individual behavior (Dunlap and McCright, 2008).

Education is not found to be predictive of policy support for relocation but plays a significant role in support for funding on education programs for emergency planning and evacuation. In particular, higher levels of education are associated with less support for emergency planning and evacuation education programs. This surprising finding (more education yields less support for emergency planning education) may suggest that people with more education already have easy access to educational information and programs on flood hazard adjustment measures such as emergency planning and evacuation, and therefore express less interest in increasing funding for these educational programs. In contrast, those with less knowledge may feel a greater need. Policy makers may thus need to make an extra effort to meet this need and to ensure that all recognize the importance of a broadly- and well-educated community for effective emergency planning and evacuation.

4.2. Analyses on the Hypothesized Path I

Multilevel regression analyses are conducted to examine effects of contextual risks on perceptions of changing hurricane strength and flooding amount as the first stage of the hypothesized Path I (H1; as shown in Fig. 1). Contextual risk factors related to hurricane strength include maximum wind speed and peak storm surge height associated with the latest landfall hurricane that affected the local county. Percentage of high-risk flood zone at the county-level is also included to explain perception of flooding amount. Moreover, a vulnerability factor, distance from the coast, is included across the analyses. Results suggest that maximum wind speed at the last hurricane landfall has significant effects on perceptions of increasing hurricane strength (detailed results in Table B of S.M.). Specifically, coastal residents who are in counties that have experienced severe storm surge flooding from the last hurricane landfall and reside near the coast are more likely to perceive higher flooding amount. Overall, the first stage of Path 1 (H1) is supported by the multilevel regression analyses.

To test the second stage of hypothesized Path I (H2), the effects of risk perceptions of changing hurricane strength and flooding amount on the two policy support measures are examined. Perceptions of increasing hurricane strength and changing flooding amount have highly significant effects on supporting relocation and funding for education program on emergency evacuation (detailed results are found in Table C of S.M., under model 1). Coastal residents who perceive increasing hurricane strength and changing flooding amount are more likely to support the two long-term flood hazard adjustment policies. These results confirm the second phase of Path I. Overall, the two-stage path analysis consistently supports our hypothesized Path I linkage of contextual risk factors to policy support through risk perceptions, as shown in Figures 2 and 3.

4.3. Analyses on the Hypothesized Path II

It is also possible that contextual risk factors can be significantly related to one's adaptation policy support (H3). Multilevel regression analyses for policy support on relocation are conducted to associate contextual risk factors with policy support directly. Distance from the coast and maximum wind speed at the last hurricane landfall that are significant predictors of perceptions of changing flooding amount fail to show significant impacts on policy support for relocation (details in Relocation models 2 in Table C of S.M.). The percentage of high risk flood zone is also insignificant to policy support on relocation. Peak height of storm surge from the last hurricane landfall on the other hand shows significant effects. Individuals who have experienced higher storm surge from the latest hurricane landfall tend to show more support for providing incentives to relocate. This finding demonstrates that individuals can retrieve the information from the latest high-impact storm surge flooding event and they are more sensitive to the memory of the storm surge flooding impact than to that of the wind in their support for relocation. A possible explanation is that during the general period of the survey (early 2012) fear for water exceeded that of wind in determining one's support for relocation. Studies addressing the relative importance of wind and water on coastal storm risk perception and response have yielded different findings (Peacock et al. 2005; Morss and Hayden, 2010; Meyer et al. 2014), with results possibly influenced by more recent events in the study locations.

Multilevel models of policy support for funding of educational programs on evacuation and emergency planning reveal that none of the contextual risk factors appear to have any significant impact on this policy support (detailed results in Emergency planning model 2 in Table C of S.M.). These results demonstrate the limited explanatory power of contextual risk factors on policy support related to evacuation and emergency planning.

In all, contextual risk factors appear to have strong effects on perceptions of changing hurricane strength and flooding amount but very limited power in influencing long-term policy support directly. Meanwhile, these two perception variables are significant factors in determining policy support. It is logical to draw the inference that contextual risk factors affect one's public policy support through perceptions. Perceptions play a powerful mediating role in one's cognitive process linking judged risks from the cues of environmental contexts to supporting policies on protective measures. The analysis does not support our hypothesized Path II that links contextual risk factors directly to policy support, except for storm surge flooding impact in the policy support for relocation in which risk perception plays only a partial mediating role.

In addition, the model comparison suggests that the model with risk perception (H2 in Path I) is better than the one with contextual risk factors (Path 2) in predicting policy support for relocation (AIC: 1.54 vs 1.57) and funding for education on evacuation and emergency planning (AIC: 0.92 vs 0.95). Values of L, k and n with AIC are shown in Table D in the S.M.. The detailed results for this framework, including unstandardized coefficients and statistical significance, are shown in Figures 2 and 3 for the two respective policy support measures.

4.4. Final Models on Adaptation Policy Support

We develop two multilevel models for the support on the two flood adaption policy measures respectively based on results from the hypothesized framework analyses (as shown in Table III). In these models, standardized coefficients are estimated to identify the relative importance of each variable. Party identity and age are the most influential factors in the two models. Perception of changing hurricane strength is slightly more important than perception of changing flooding amount in policy support for relocation and increasing funding for emergency planning and evacuation. Education, gender, race and the residual effect of storm surge flooding from the last landfall hurricane seem to have a small influence on one's support for relocation. However education and race are very important factors determining a respondent's support for increasing funding for education on emergency planning and evacuation.

To help put the model results in overall perspective, we display variations in the probability of policy support with different risk perceptions based on our multilevel regression models (Figure 4). The first notable finding is that both the perception of changing flooding amount and perception of changing hurricane strength play a crucial role in increasing the probability of supporting relocation, ranging from 56 percent supporting relocation among those perceiving a decrease in either hurricane strength or flooding, to 69 or 70 percent supporting relocation among those perceiving increased hurricane strength or flooding amount, respectively. The results for support of education programs shows a similar response to heightened risk perception, but with a much higher level of baseline support. Perceptions of both higher hurricane strength and flooding each yield increased support for education programs from 80 percent (for those who perceive decreases in risk) to 88 percent (perceived increase).

5. Conclusion

With the combination of growing population concentration in the coastal zone and increasing flooding risks brought by climate change, it is imperative to examine what motivates individuals to support certain measures to better deal with increasing flooding risks. In this study, we focus on individuals' support for two different long-term policy measures, namely, providing incentives for relocation and increasing funding for education on emergency planning and evacuation. By merging contextual flood risk data with survey data, we attempt to reveal some relationships between nature and society, specifically, the influence of contextual risks on societal flood adaptive decisions. We have made three major findings.

First, the relationship between contextual flooding risks and long-term flood hazard adjustment policy support is not straightforward. Rather, the contextual flooding risks, indicated by distance from the coast, maximum wind speed and peak height of storm surge associated with the last hurricane landfall, and percentage of high-risk flood zone per county, impact support on both policy measures through perceptions of flood-related risks. In other words, perceived risks play a mediating role bridging the contextual flood-related risks and policy support to address these risks. Specifically, the maximum wind speed from the last hurricane landfall is found to be significantly related to perceptions of increasing hurricane strength. Peak storm surge from the last hurricane landfall and distance from the coast are found to be significantly related to perception of changing flooding amount. None of these contextual risk factors appear to exert significant impacts on policy support for the two measures directly, with the only exception that peak height of storm surge associated with the last hurricane landfall has a significant positive association with policy support for relocation, even in the presence of risk perceptions. The strength of storm surge effect on support for relocation dwindles when including risk perceptions in the models, which reinforces the inference that risk perception is the mediator linking contextual risks and policy support. This finding has two general theoretical implications. First, it highlights the importance and justifies the necessity to conduct studies on environmental risk perceptions and understand their relationship with the environmental context. Second, it suggests that the seemingly insignificant results of contextual risk factors on policy support should not be dismissed at outset. Instead, further investigation is needed to examine the relationship between the environmental context and individuals' behavior intention/policy support. In the present study, we specifically test the mediating role of risk perceptions. There are however alternative paths through which the contextual risk factors may exert influence on one's behaviors to reduce risks. These other possible routes including local policies, media, and social norms, should be explored in future studies. In addition, the finding that the peak height of storm surge associated with the last hurricane landfall has a strong influence has important policy implications. When urging residents to adopt proper long-term flood hazard adjustment measures, it may be more effective to place emphasis on the damaging power of storm surge from hurricanes, rather than other storm event attributes.

Second, some socio-demographic characteristics including age, gender, race and partisanship stand out as important predictors on individuals' policy support on long-term flood adaptive measures. The highly significant negative effects of age on policy support have an important policy implication. It may be more challenging for policy makers to motivate the elder to support the policies on relocation and education on evacuation. Females are also more likely to support the policies on relocation and education on evacuation to adapt to increasing risks. Racial minorities, compared to whites, are more likely to support these two measures. Republicans are less inclined to supporting these two policies. The findings about the socio-demographic background sends a crucial message to policy makers. The local government needs to make particular effort to reach out to those who live under the threat of flooding but are reluctant to support long-term flood hazard adjustment policies, and to allocate more educational resources to help them understand potential flooding risks and the importance of precautionary measures and community preparedness.

The research on long-term flood hazard adjustment policy support is far from being complete. In this study, we focus only on the impact of physical conditions on one's flood adaptation policy support. Future studies need to take into consideration social constructs. Local plans/policies, community socio-demographic makeup, social cohesion, and economic conditions vary geographically. How these socio-economic factors impact one's adaptation /policy support needs to be further investigated. Furthermore, future studies can associate objective risk factors at the household level (Botzen et al., 2009), such as flood hazard at the property level, ground elevation, and front door elevation, with their flood adaptation decisions.

Finally, the study of public support for flood adaptation policies can be extended across different countries that are also vulnerable to flooding, such as the Netherlands, Vietnam, and Bangladesh. The mediating effect of risk perception between contextual flood risk and policy support should be examined across nations.

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Table I. Individual-level variables

Individual-level Variables	Code	Frequency	Percent (%)
Socio-demographic			
Age			
18-24	1	79	2.0
25-34	2	205	5.3
35-44	3	393	10.2
45-54	4	733	19.0
55-64	5	981	25.4
65 and over	6	1431	37.1
Gender			
Female	1	2305	59.8
Male	0	1551	40.2
Race			
White	1	2797	72.5
Others	0	1055	27.4
Education			
Less than HS	1	220	5.7
HS Degrees	2	770	20.0
Some College	3	1214	31.5
College Degree	4	1609	41.7
Income			
Under $10,000	1	186	4.8
$10,000 - $19,999	2	255	6.6
$20,000 - $29,999	3	292	7.6
$30,000 - $39,999	4	273	7.1
$40,000 - $49,999	5	255	6.6
$50,000 - $74,999	6	506	13.1
$75,000 - $99,999	7	434	11.3
$100,000 or more	8	653	16.9
Partisanship			
Democrat	-1	1100	28.5
Independent	0	1232	32.0
Republican	1	1246	32.3
Distance from the coast			
Adjacent/On the water	1	379	9.8
Near the water/within 1 - 2 miles	2	591	15.3
Within 2 - 5 miles	3	447	11.6
5 - 10 miles	4	592	15.4

11 - 30 miles	5	992	25.7
31 – 60 miles	6	545	14.1
More than 60 miles	7	224	5.8
Perceptions of Flooding Amount and Hurricane Strength			
Flood Amount			
Decreased	-1	658	17.1
About the same	0	2195	56.9
Increased	1	902	23.4
Hurricane Strength			
Not as strong	-1	521	13.5
About as strong	0	1634	42.4
Stronger	1	1466	38.0
Policy Support			
Relocation			
Oppose	-1	1311	34.1
Don't know	0	219	5.7
Support	1	2312	60.2
Increasing funding for emergency planning and evacuation			
Oppose	-1	672	17.5
Don't know	0	74	1.9
Support	1	3104	80.6

Table II. Correlations of the dependent and independent variables

	Age	Gender	Race	Education	Income	Party	Distance	Hurricane	Flooding	Relocation	Evacuation
Age	1.00										
Gender	-0.02	1.00									
Race	0.15***	-0.06***	1.00								
Education	-0.03	-0.06***	0.13***	1.00							
Income	-0.07***	-0.17***	0.22***	0.47***	1.00						
Party	0.01	-0.07***	0.38***	0.13***	0.25***	1.00					
Distance	-0.12***	0.06***	-0.10***	-0.07***	-0.05*	-0.03*	1.00				
Hurricane	0.05**	0.05**	-0.01	0.00	-0.00	-0.07***	-0.02	1.00			
Flooding	0.00	0.05**	-0.05**	-0.01	-0.01	-0.06***	0.01	0.24***	1.00		
Relocation	-0.11***	0.08***	-0.09***	-0.01	-0.06**	-0.13***	-0.00	0.11***	0.10***	1.00	
Evacuation	-0.10***	0.08***	-0.13***	-0.12***	-0.12***	-0.17***	0.04*	0.10***	0.07***	0.26***	1.00

(Party: party identity; Distance: distance from the coast; Hurricane: perception of changing hurricane strength; Flooding: perception of changing flooding amount; Relocation and Evacuation are the two respective dependent variables)

* for Ho rejected at the 0.05 level, ** for Ho rejected at the 0.01 level, and *** for Ho rejected at the 0.001 level.

Table III. Standardized coefficients of the final mixed-effect ordered-logit models

Variable	Relocation	Education on Evacuation and Emergency Planning
Socio-Demographic		
Age [+/-]	-0.231***	-0.256***
Gender: female [+/-]	0.129*	0.156*
Race: white [+/-]	-0.087*	-0.219*
Education [+/-]	0.062	-0.132
Income [+]	-0.113	-0.159
Partisanship [+/-]	-0.188***	-0.361***
Perceptions of Risks		
Hurricane strength [+]	0.176***	0.235***
Flooding amount [+]	0.168**	0.183**
Contextual Risks		
Distance from the coast [-]	-0.062	0.076
Maximum wind speed [+]	-0.039	-0.064
Storm surge [+]	0.135*	-0.027
Percentage of high risk flood zone per county [+]	0.075	0.025
N	1666	1671

* for Ho rejected at the 0.05 level, ** for Ho rejected at the 0.01 level, and *** for Ho rejected at the 0.001 level.

+ indicates positive hypothesized effect; - indicates negative hypothesized effect

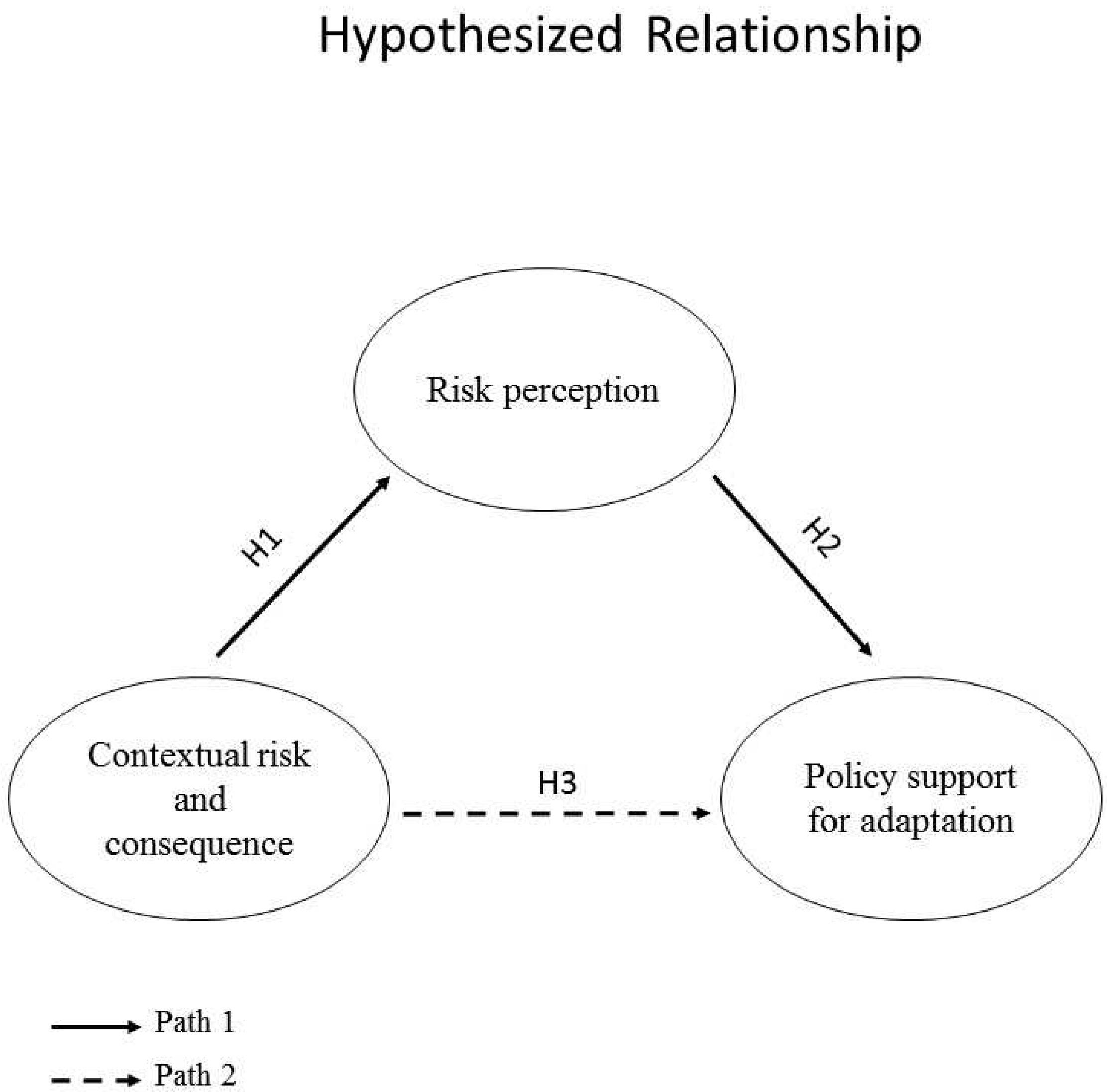


Figure 1. Hypothesized relationships between contextual risk and consequence, risk perception, and policy support for risk adaptation.

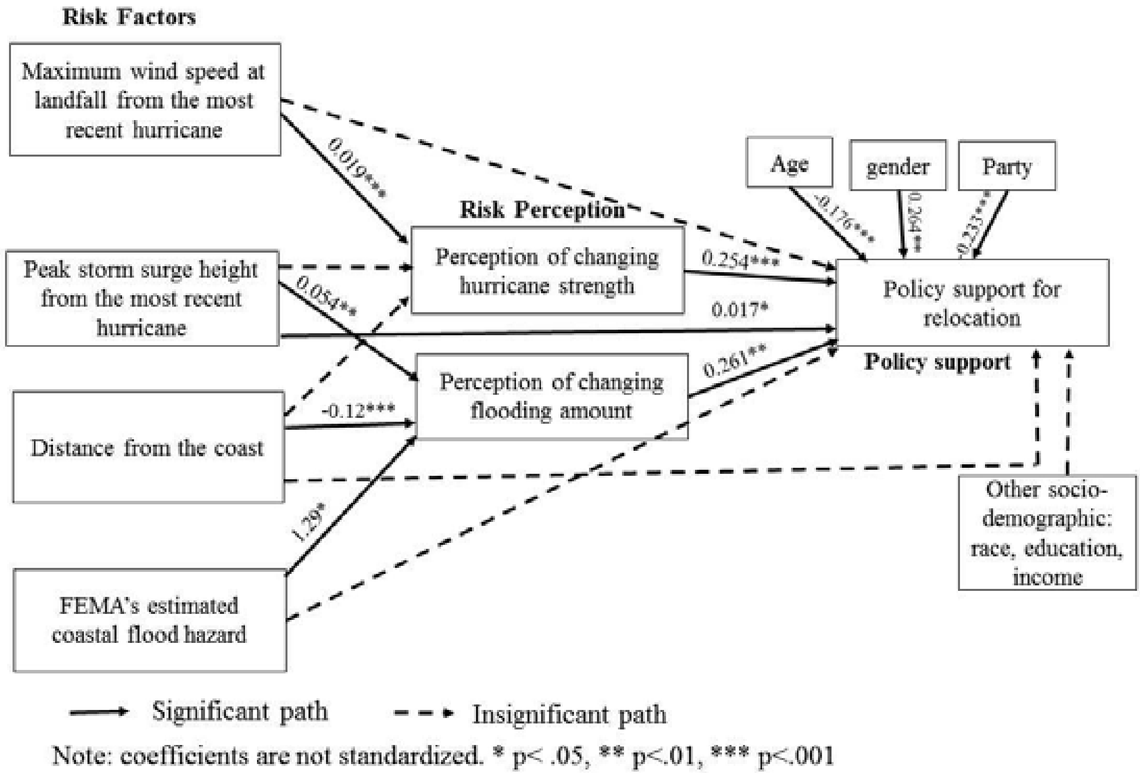


Figure 2. Path analysis to test the path I and path II in the conceptual framework for policy support on relocation. (The numbers in each arrows refers to the coefficients of the model that are not standardized).

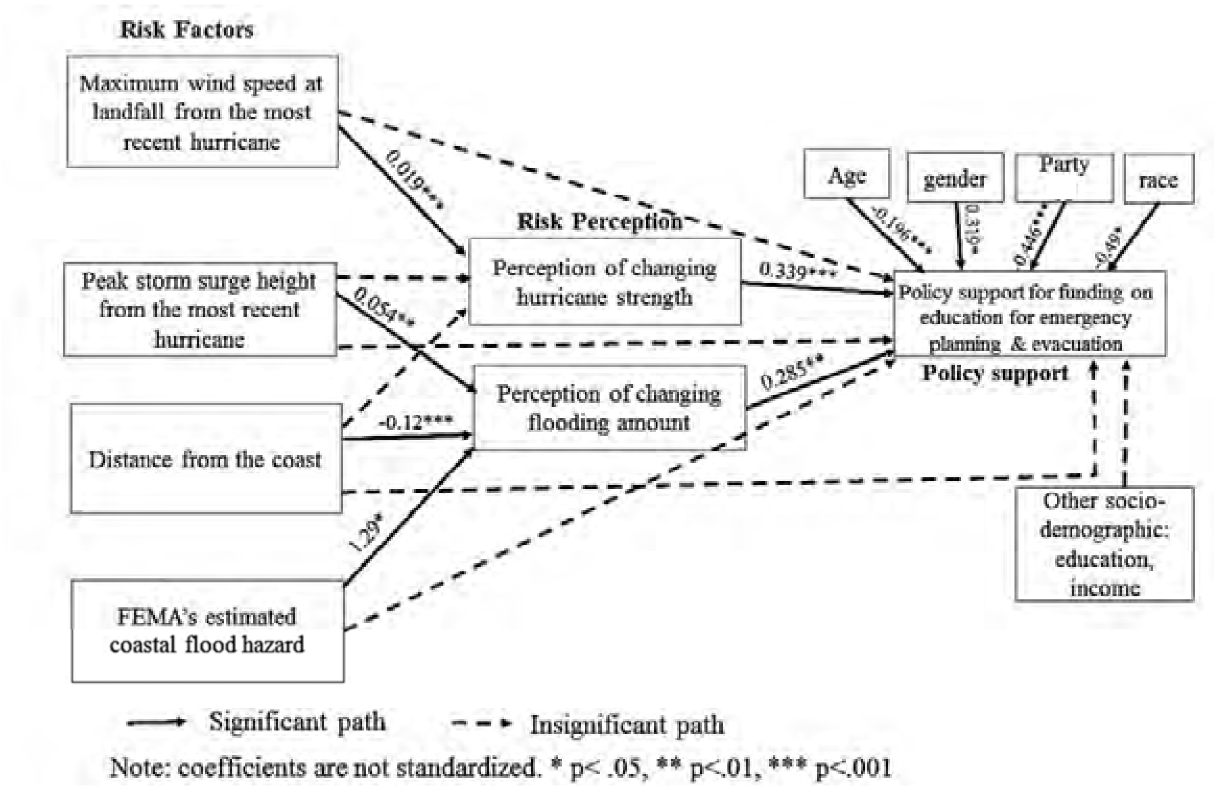


Figure 3. Path analysis to test the path I and path II in the conceptual framework for policy support on funding on education for emergency planning and evacuation.

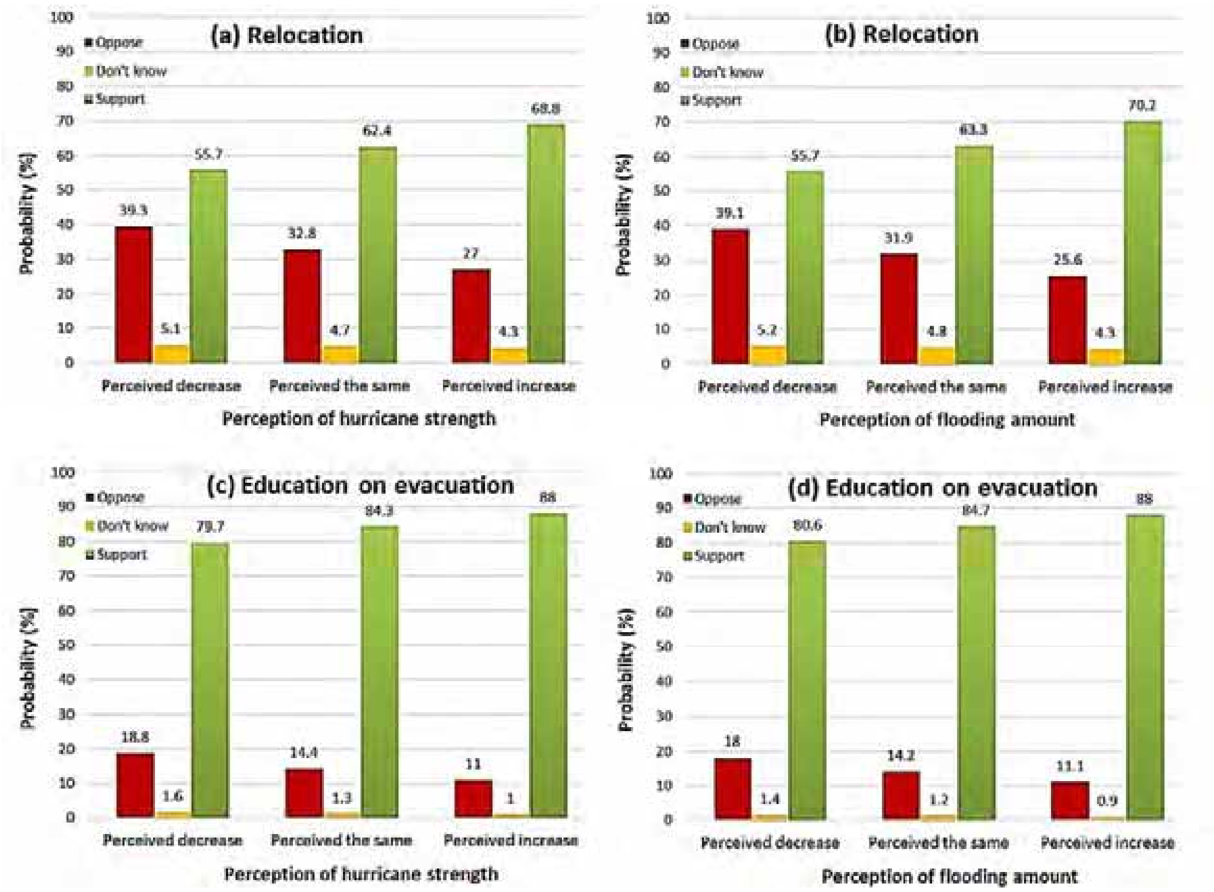
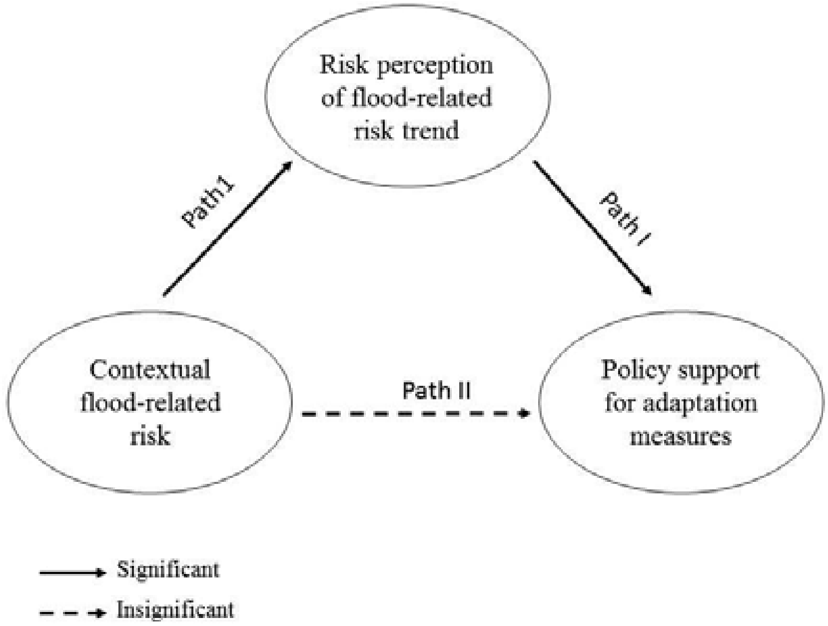


Figure. 4. Variation in probability (%) of policy support for: (a) & (b) relocation and (c) & (d) funding for education on emergency planning and evacuation with different risk perceptions of hurricane strength and flooding amount. (The other variables are fixed at the mean).


Risk perception of flood-related risk trend
Path1
Path I
Contextual flood-related risk
Path II
Policy support for adaptation measures
Significant
Insignificant