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An empirical analysis of hurricane evacuation expenditures

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Abstract   Very little is known about evacuation expenditures at the household level even though improved understanding of those expenditures can provide inputs for designing more effective evacuation programs and planning. We conducted a household survey in Harris and Galveston counties in Texas after being hit by hurricane Ike (one of the costliest hurricanes that have impacted the USA) to investigate the determinants of evacuation expenditures. Results suggest that household income, hurricane risks and household size are significant determinants of household evacuation expenditures. Our empirical analyses indicate that an average household would spend approximately $194 if a voluntary evacuation order is received and more than $300 if a mandatory evacuation order is received. These estimates may provide inputs for future hurricane evacuation planning.

Keywords   Natural hazards · Evacuation expenditures · Hurricane evacuation · Emergency management · Revealed preferences · Stated preferences

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1 Introduction

Hurricanes can be extremely destructive due to storm surge, damaging winds and flooding (Powell and Reinhold 2007). In the event of a hurricane, evacuation may be one of the most effective alternatives to reduce hurricane-related fatalities. Consequently, evacuation orders have become an important policy tool in areas vulnerable to hurricanes (e.g., the coastal south region of the USA). This is more so in major coastal cities where a large number of people may need to evacuate in a short period of time. Evacuation orders are justified as it allows ensuring safety of people residing on the path of the storm. However, as Whitehead (2003) argued, it is also policy relevant to note that hurricane evacuations impose unexpected costs (e.g., expenditures on transportation, food and lodging, stress and coping with unusual lifestyle) on households in vulnerable areas.

Surprisingly, little is known about evacuation expenditures at the household level even though improved understanding of those expenditures can provide inputs for designing more effective evacuation programs and planning. Whitehead (2003) presents one of the few studies on evacuation costs, which used joint models of revealed and stated behavior data gathered through a telephone survey. In that survey, respondents were asked whether they evacuated when hurricane bonnie hit North Carolina in 1998. Respondents were also presented with hypothetical scenarios of varying storm intensity and asked whether they would evacuate under such conditions and how much it would cost them for evacuation. Evacuation probabilities were calculated based on a number of probit models and then used to estimate weighted averages of evacuation costs. Estimated costs (including lodging, meals, entertainment and travel time) varied from $211 to $292 for different storm categories.

Czajkowski (2011) looked into the timing of evacuation before a hurricane landfall and showed that over time the cost of evacuation substantially changes; it initially increases, reaches to a peak and then decreases. The evacuation costs also vary with different categories of hurricanes, and the costs associated with major hurricanes are much higher compared to that of minor hurricanes. Czajkowski (2011) also estimated the expected costs of not evacuating and found that the expected costs of not evacuating are substantially higher than the expected costs of evacuating. This implies the social benefits and crucial needs of efficient organization of evacuation activities.

This study intends to contribute to the thin literature on evacuation expenditures. To do so, a telephone survey was implemented to gather both revealed expenditures data from households who evacuated their homes when hurricane Ike hit the coast of Texas in 2008 and stated (i.e., hypothetical) expenditures from households who did not evacuate. We follow a different approach than Whitehead (2003) in that revealed and stated data are combined to directly estimate empirical models of evacuation expenditures. A number of regression models are estimated to identify the determinants of evacuation expenditures with emphasis on household income and hurricane risks (represented by evacuation orders). Findings indicate that household income, hurricane risks and household size are the main determinants of household evacuation expenditures. Results also suggest that an average household would spend approximately $194 if a voluntary evacuation order is received and more than $300 when the evacuation order is mandatory.

2 Background and survey design

On September 13, 2008, hurricane Ike made landfall along the north end of Galveston Island, Tx, with winds of 95 knots and with an estimated surge of 15–20 feet. Texas, Louisiana and Arkansas suffered the most from Ike, although the hurricane also affected

other regions including Florida and the Ohio valley. At least 20 deaths were directly related to Ike in Texas, Louisiana and Arkansas. Insured damage was estimated to be approximately $12.5 billion dollars in those three states. The total damage caused by Ike was estimated at about $24.9 billion, one the costliest hurricanes since hurricane Andrew in 1992.

In 2010, researchers at the Florida International University completed 1099 telephone interviews from a random probability sample of households located in Harris and Galveston counties in Texas with a response rate of 36 %. A geocoded zip code area-stratified sampling frame was used to oversample areas of higher storm surge risk (delineated by Federal Emergency Management Agency, FEMA). More interviews were done proportionally in zip code areas that are lower elevation and near to the coast.

The survey questionnaire asked about behaviors adopted to minimize the risk of being affected by a hurricane in 2008 and specifically to deal with Ike once that hurricane hit the coast of Texas. Respondents who evacuated due to Ike were asked to report their evacuation expenditures (i.e., expenditures on transportation, food and lodging). Alternatively, those respondents who did not evacuate were asked to state how much they would have spent if they had decided to evacuate. Stated evacuation expenditures can be treated as additional data points to increase sample size and thus improve the efficiency of estimates. However, the hypothetical nature of stated evacuation expenditures can be a concern. Hence, it is necessary to identify and correct for hypothetical bias in the stated behavior of predicted evacuation expenditures. We explain our approach to deal with potential hypothetical biases in the next section.

The survey also gathered information on covariates of evacuation expenditures. All respondents were asked whether their housing unit was elevated to deal with storm surge and about preparations implemented previous to the hurricane season such as having material to protect their windows. The questionnaire also asked respondents whether an order of evacuation was issued for their neighborhoods for Ike, and about the type of evacuation order they received (i.e., voluntary or mandatory). In addition, respondents reported how important hurricane effects (e.g., storm surge), crime (especially looting of empty house after evacuation) and pets were for them in deciding whether to evacuate or stay at home when facing a hurricane like Ike. Finally, the survey gathered information about the socioeconomic characteristics of respondents.

3 Analytical framework and empirical modeling

Our theoretical model is based on the assumption that perceived hurricane risks have a negative impact on households' utility due to potential economic losses, physical injuries and emotional distress. Perceived hurricane risks are directly associated with the actual probability of being affected by a hurricane and negatively related to averting measures adopted by the household to cope with hurricanes. Hence, households choose the averting measures that maximize their utility subject to their budget constraint. The solution to this household problem implies that the optimal choice of averting behaviors depends on hurricane risk, household income and costs of averting measures. Given that perceived risks increase with the probability of being affected by a hurricane, it is expected that households will adopt averting behaviors to reduce perceived risks and thus maximize their utility. Consistent with standard utility theory, the implementation of a given averting measure decreases with its costs and increases with household income.

While a household can implement different measures to cope with hurricane risks, the focus here is on household expenditures on hurricane evacuation, arguably the most

effective strategy to cope with hurricanes. Evacuation expenditures are modeled following a semilog specification:

$$\text{LNEXP} = X\beta + e \tag{1}$$

where LNEXP is the natural logarithm of household expenditures on evacuation. X represents a matrix of covariates including characteristics of respondents and their households, indicators of storm severity as proxy of actual risks to be affected by hurricane Ike, and respondents' attitudes regarding hurricanes, β is a conformable vector of coefficients to be estimated, and e is the error term assumed to be normally distributed (i.e., $e \sim N[0, \sigma^2]$).

Given that our revealed and stated evacuation expenditures data come from different subsamples (i.e., evacuees and non-evacuees, respectively), revealed and stated evacuation expenditures are stacked, treating stated expenditures as additional data points, in order to estimate Eq. 1. This increases the sample size and consequently improves the econometric efficiency of evacuation expenditures models here estimated (Whitehead 2005b; Whitehead et al. 2008). Both revealed and stated behavior data may have their own issues. For example, the inclusion of stated preference data comes with some concerns, particularly the hypothetical bias which results from stated choices that do not reflect budget constraints on behavior (see Azevedo et al. 2003). However, as Whitehead et al. (2008) argue, revealed preference data provide real behavior but often limited to historically occurred events. By combining revealed and stated behavior data, the limitations of both types of data can be minimized while taking full advantage of their corresponding strengths (Brooks and Lusk 2010; Eiswerth et al. 2000; Whitehead 2005a, b).

Table 1 shows the definition and descriptive statistics of variables included in the matrix of covariates of evacuation expenditures (i.e., X). The variables INCOME and INCOMESQ are included to investigate the relationship between evacuation expenditures and household income. Following Whitehead (2005a), the binary indicators VOLUNTARY and MANDATORY are included as objective hurricane risk variables. Household and respondent characteristics such as HHSIZE, EDUC, OWNER, BLACK and COLOR are also included to control for potential heterogeneity across individuals and their households. The binary indicators IMPSURGE, IMPCRIME and IMPPETS are included to control for attitudes that can affect household averting behaviors implemented to cope with hurricane risks. The binary indicators WINDOWPREP and HOUSEPREP are also included because it could be expected that averting measures implemented prior to the hurricane season can also affect evacuation choices (see Solís et al. 2010). Finally, the binary indicator SP is included to investigate differences between revealed and stated evacuation expenditures.

In addition to estimating evacuation expenditures of a representative household, the following hypotheses are tested against the null hypothesis of no effect:

H1: $\beta_{\text{INCOME}} > 0$
H2: $\beta_{\text{MANDATORY}} > \beta_{\text{VOLUNTARY}} > 0$
H3: $\beta_{\text{SP}} > 0$

The first hypothesis (H1) is derived from our theoretical framework that indicates that the implementation and intensity of averting measures such as expenditures on hurricane evacuation increase with household income. The variable INCOMESQ is included to further investigate the type of relationship between evacuation expenditures and household income (i.e., whether that relationship is linear or quadratic). Because no specific hypothesis is made on that relationship, β_{INCOMESQ} remains to be empirically estimated.

Table 1 Variables definition and descriptive statistics

Variables	Definition	Mean	SD
LNEXP	Natural logarithm of evacuation expenditures	5.675	1.630
INCOME	Household's annual income in intervals of $10,000 (1 = $10,000 or less … 11 = over $100,000)	6.69	3.446
INCOMESQ	Household's annual income squared	56.581	46.280
VOLUNTARY	If the respondent received a voluntary order to evacuate (1 = yes, 0 = otherwise)	0.260	0.439
MANDATORY	If the respondent received a mandatory order to evacuate (1 = yes, 0 = otherwise)	0.314	0.465
HHSIZE	The number of individuals living in the respondent's household	2.826	1.446
EDUC	If the respondent has a college degree (1 = yes, 0 = otherwise)	0.519	0.501
OWNER	If the respondent is owner of the house (1 = yes, 0 = otherwise)	0.829	0.377
BLACK	If the respondent's race is black (1 = yes, 0 = otherwise)	0.186	0.390
COLOR	If the respondent's race is other than white or black (1 = yes, 0 = otherwise)	0.043	0.202
IMPSURGE	If the possibility of flooding or storm surge is extremely important in deciding what to do if a hurricane is approaching (1 = yes, 0 = otherwise)	0.426	0.495
IMPCRIME	If being able to protect his/her home from crime and looting is extremely important in deciding what to do if a hurricane is approaching (1 = yes, 0 = otherwise)	0.426	0.495
IMPPETS	If the needs of pets or animals are extremely important for the respondent in deciding what to do if a hurricane is approaching (1 = yes, 0 = otherwise)	0.357	0.480
WINDOWPREP	If the respondent's household was prepared to protect windows against hurricanes (1 = yes, 0 = otherwise)	0.523	0.500
HOUSEPREP	If the respondent's home or building was elevated on pilings or fill material to raise it above flood water (1 = yes, 0 = otherwise)	0.202	0.402
SP	Type of expenditure data (1 = stated, 0 = revealed)	0.558	0.498

The theoretical framework used here also indicates that evacuation expenditures increase with the risk of being hit by a hurricane, as stated in hypothesis H2. According to this hypothesis, households who received an order of voluntary evacuation would spend more resources on hurricane evacuation than those households who did not receive any evacuation order, as the former are assumed to face higher hurricane risks. Moreover, households who received a mandatory order of evacuation are expected to spend the highest amount of resources on evacuation given that they faced the highest hurricane risks relative to households who received a voluntary evacuation order and households who did not receive an evacuation order at all.

As discussed above, there are gains from combining revealed and stated preference data to analyze evacuation expenditures. However, there are also particular concerns about the hypothetical nature of stated preference data (see Azevedo et al. 2003). According to hypothesis H3, households who did not evacuate during Ike and yet provided an estimate of evacuation expenditures as if they had evacuated may overestimate such hypothetical expenditures presumably to influence potential government transfers to help in hurricane evacuations. Thus, the indicator SP is included to test the hypothetical bias hypothesis (H3)

and correct it if such bias exists. Thus, it allows us to estimate the magnitude of hypothetical bias and adjust the predicted evacuation expenditures in order to provide more precise estimates.

4 Results

Table 1 shows the average profile of respondents. Almost 83 % of respondents lived in their own housing unit, with an average household size of approximately 2/3 members. Almost 52 % of respondents had a college degree. A majority of respondents identified themselves as white (77 %), less than 19 % identified themselves as black, and 4.3 % reported to have a racial background other than white and black. More than 20 % of respondents were living in a home or building that was elevated above flood water, and more than 52 % reported being prepared to protect the windows of their housing units against hurricanes in 2008 (when Ike hit Texas). Almost 56 % of respondents did not evacuate when Ike hit their localities, even though more than 57 % received a voluntary or mandatory order to evacuate.

Table 2 presents four empirical models estimated to investigate evacuation expenditures using the pooled sample of respondents. Due to a large number of missing observations on evacuation expenses and other relevant covariates, the sample size for multivariate regressions reported in Table 2 has been significantly reduced. Model 1 includes income and hurricane risk variables, as well as household and respondent characteristics and attitudes. Model 2 extends the specification of Model 1 by including hurricane preparedness indicators for risk-averting measures adopted prior to the hurricane season. In both Model 1 and Model 2, error terms are assumed to be normally and identically distributed. Model 3 and Model 4 follow the same specification than Model 1 and Model 2, respectively. However, given that revealed and stated preference data may also differ in terms of error variances (see Azevedo et al. 2003), Model 3 and Model 4 allow error variances to be different across revealed and stated evacuation expenditures. Results show a considerable degree of robustness across all models, but standard errors of estimated coefficients in Model 3 and Model 4 show an improvement with respect to estimates from Model 1 and Model 2 as a result of correcting for heteroscedasticity across stated and revealed preference data. F tests indicate that error terms show variances that are statistically different (at 1 % level) across revealed and stated expenditure data ($F = 2.006$ for Model 3 and $F = 1.831$ for Model 4). This indicates that Model 3 and Model 4 are more appropriate for estimating evacuation expenditures given the nature of our data.

Estimated models suggest that three factors have a significant impact on evacuation expenditures at the household level: household income, hurricane risks and household size. The income effect on evacuation expenditures shows a quadratic, concave form as indicated by positive coefficients of INCOME and negative coefficients of INCOMESQ across all models. This provides partial evidence in support of hypothesis H1 given that evacuation expenditures increase with household income below the threshold of $80,000 per year approximately (see Fig. 1). Above that income threshold, evacuation expenditures seem to decrease. Presumably richer households may afford averting measures other than evacuation (e.g., making their housing unit more resistant to hurricanes) and can own other housing units that can be used to go after evacuation, thus showing lower expenditures on lodging and food. This result is somewhat different from previous findings that suggest that household income is not a determinant of evacuation choices in both real and hypothetical

Table 2 Pooled models of evacuation expenditures

	Model 1	Model 2	Model 3	Model 4
INCOME	0.315 (0.158)**	0.368 (0.161)**	0.323 (0.149)**	0.368 (0.153)**
INCOMESQ	−0.021 (0.011)*	−0.025 (0.012)**	−0.021 (0.011)*	−0.024 (0.011)**
VOLUNTARY	0.476 (0.260)*	0.481 (0.265)*	0.492 (0.243)**	0.482 (0.249)*
MANDATORY	1.051 (0.290)***	0.970 (0.294)***	1.002 (0.282)***	0.930 (0.286)***
HHSIZE	0.132 (0.071)*	0.137 (0.074)*	0.141 (0.069)**	0.146 (0.070)**
EDUC	−0.119 (0.234)	−0.161 (0.237)	−0.063 (0.222)	−0.113 (0.226)
OWNER	0.035 (0.290)	0.015 (0.296)	0.0001 (0.276)	−0.040 (0.280)
BLACK	0.425 (0.266)	0.400 (0.268)	0.487 (0.254)*	0.459 (0.255)*
COLOR	−0.309 (0.503)	−0.247 (0.505)	−0.418 (0.476)	−0.346 (0.477)
IMPSURGE	−0.147 (0.229)	−0.188 (0.233)	−0.127 (0.218)	−0.171 (0.222)
IMPCRIME	0.255 (0.234)	0.284 (0.239)	0.213 (0.223)	0.233 (0.227)
IMPPETS	0.007 (0.232)	0.084 (0.234)	0.041 (0.220)	0.110 (0.223)
WINDOWPREP	–	−0.177 (0.209)	–	−0.151 (0.201)
HOUSEPREP	–	−0.009 (0.256)	–	−0.005 (0.245)
SP	0.977 (0.248)***	0.853 (0.255)***	0.955 (0.244)***	0.843 (0.249)***
Constant	3.286 (0.539)***	3.363 (0.554)***	3.247 (0.519)***	3.332 (0.532)***
Observations	265	258	265	258
Between-subsamples heteroscedasticity	Uncorrected	Uncorrected	Corrected	Corrected

***, **, * imply significance at 1, 5 and 10 % levels, respectively; numbers in parentheses are corresponding standard errors
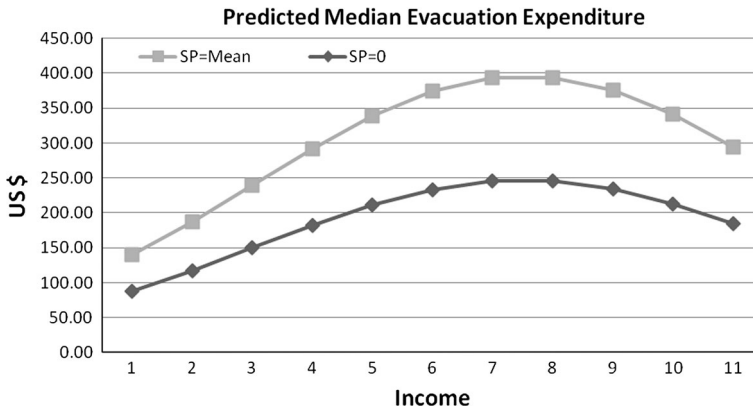
Fig. 1 Predicted median evacuation expenditure by income. *Notes*: given that median evacuation expenditures estimated at the average of explanatory variables (i.e., SP = mean) may be subject to hypothetical bias, those estimates were corrected by setting the SP indicator equal to zero

settings (e.g., Petrolia et al. 2011; Solís et al. 2010; Whitehead 2003). It is worth noting that those studies only investigated linear income effects and did not investigate the quadratic nature of income effects (Kellenberg and Mobarak 2008).

In accord with hypothesis H2, both indicators on hurricane risks, VOLUNTARY and MANDATORY, are positive and statistically significant (see Table 2). Moreover, estimated coefficients on MANDATORY are greater than VOLUNTARY coefficients. This indicates that evacuation expenditures increase with hurricane risks. Landry et al. (2011), Petrolia et al. (2011), Shaw and Baker (2010) provide similar evidence based on stated preferences data, indicating that households' willingness to expend resources on averting behaviors increases with the level of hurricane risks. Whitehead (2003) also found that households who received a mandatory order of evacuation due to hurricane bonnie in 1998 were more likely to evacuate than households who did not receive such order. However, in contrast to our results, Whitehead (2003) found that voluntary evacuation orders did not impact evacuation choices.

Given the potential bias of hypothetical responses, the four models include the binary indicator, SP to estimate the magnitude (and direction) of hypothetical bias related to stated evacuation expenditures from those respondents who did not evacuate. In support of the hypothesis that stated data may show hypothetical bias (H3), estimated coefficients on SP are positive and statistically significant at 1 % level (see Table 2). This suggests that, compared to individuals who evacuated during Ike, individuals who did not evacuate tend to inflate their estimates regarding potential household expenditures to evacuate (see Whitehead 2003 for similar results on hypothetical bias of stated evacuation).[1]

As it can be expected, results also indicate that evacuation expenditures increase with household size (i.e., estimated coefficients on HHSIZE are positive and significant).

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[1] The decision to evacuate can be associated with personal and household characteristics that also affect household expenditures. If some of those characteristics are unobserved (i.e., included in the error term), estimated coefficients on SP can suffer from endogeneity bias. To address this issue, we estimated regime-switching models using attitudes toward hurricanes (i.e., IMPSURGE, IMPCRIME and IMPPETS) as instruments. Correlation estimates and Wald tests do not yield enough evidence to support the hypothesis that SP is an endogenous variable. Consequently, it can be concluded that estimated coefficients on SP here presented are not biased.

Households with a larger number of members would spend more on food and lodging, as well as on transportation. Results also suggest that black respondents tend to spend more on evacuation than white individuals, although estimated coefficients on BLACK are statistically significant only at 10 % level in Models 3 and 4. Other factors are statistically insignificant suggesting that corresponding characteristics and attitudes do not affect evacuation expenditures.[2]

Table 3 shows median evacuation expenditures that are predicted using the average profile of respondents.[3] Expenditure estimates are corrected for hypothetical biases by setting the indicator SP equal to zero. Corrected estimates are more conservative and arguably more precise. On average, the difference between stated and revealed evacuation expenditure (extent of hypothetical bias) is of approximately $109–$124, depending on the model used to predict the median evacuation expenditures. Conservative estimates indicate that evacuation expenditures are above $170 for the average household. Figure 1 shows how the median evacuation expenditures vary across income levels based on estimates from Model 4. Both uncorrected and corrected estimates show that the median evacuation expenditures increase at a decreasing rate, reaching a maximum level when the household income is $60,000–$80,000. Conservative estimates (i.e., corrected for hypothetical bias) indicate that the highest median evacuation expenditure is approximately $245, almost $150 below the corresponding uncorrected estimate. Households earning $10,000 or less show the lowest evacuation expenditure at $87.

Figure 2 presents the median evacuation expenditures for each level of hurricane risk here represented by the type of evacuation order issued. Estimates that are corrected for hypothetical bias (i.e., SP = 0) indicate that households facing a storm that do not have an evacuation order would spend almost $120 to evacuate. When the hurricane is severe enough to issue a voluntary order of evacuation, an average household would spend approximately $194 to evacuate. As expected, the median evacuation expenditure for a mandatory order increases up to $304, that is, a difference of $110 with respect to evacuation expenditures in the case of a voluntary order of evacuation.

5 Discussions and conclusions

This study utilized data on evacuation expenditure from both evacuees (who reported their actual evacuation expenses) and non-evacuees (who stated their evacuation expenses if they had decided to evacuate) during hurricane Ike. We combined revealed (actual) and stated (hypothetical) evacuation expenditures data to improve the econometric efficiency of empirical models for analyzing hurricane evacuation expenditures at the household level. Findings identified three determinants of evacuation expenditures: (1) household income, (2) hurricane risks and (3) household size. The combined analysis of revealed and

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[2] Results based on the stated expenditure data are similar in terms of sign and significance of estimated coefficients, with the exception of MANDATORY which is statistically insignificant presumably because there were few households who did not evacuate after receiving a mandatory evacuation order. In contrast, MANDATORY is the only factor to be found statistically significant when revealed expenditures are used alone. Those estimates are improved by using pooled expenditure data as suggested by Whitehead et al. (2008).

[3] Since evacuation expenditures are modeled following a semilog specification, predicted values represent the median of the distribution rather than the average. The median is a more conservative estimate of evacuation expenditures given that expenditure distributions tend to be skewed to the right due to the existence of outliers.

Table 3 Predicted median evacuation expenditures (US$)

	Model 1	Model 2	Model 3	Model 4
SP = mean	294.96	291.47	294.95	291.47
SP = 0	170.91	181.05	173.04	182.05

Given that median evacuation expenditures estimated at the average of explanatory variables (i.e., SP = mean) may be subject to hypothetical bias, those estimates were corrected by setting the SP indicator equal to zero
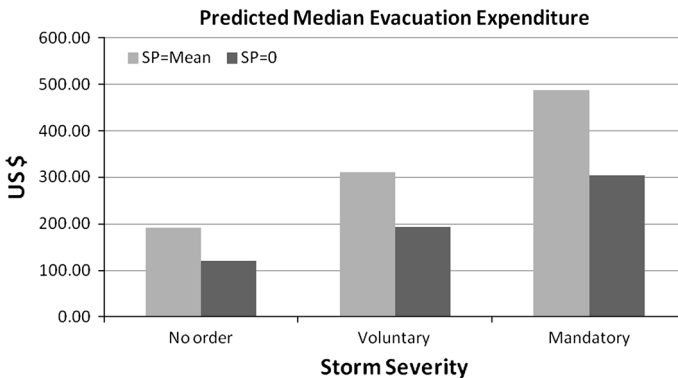
Fig. 2 Predicted median evacuation expenditure by storm severity. *Notes*: given that median evacuation expenditures estimated at the average of explanatory variables (i.e., SP = mean) may be subject to hypothetical bias, those estimates were corrected by setting the SP indicator equal to zero

stated expenditures data comes with certain costs. Results indicate that stated evacuation expenditures tend to be higher than revealed expenditures presumably because stated expenditures are subject to hypothetical bias. We estimated the magnitude of hypothetical bias and corrected in order to provide more conservative and accurate estimates of household expenditures for hurricane evacuation.

Household income affects evacuation expenditures in a nonlinear fashion. Evacuation expenditures increase with household income until a threshold of approximately $80,000, and then evacuation expenditures decrease with rising income. As Lazo et al. (2010) have argued, richer households may live in properties that are well built and less vulnerable to hurricanes and may be more reluctant to leave their property unprotected. If that is the case, richer households can be expected to spend less in hurricane evacuation compared to less affluent households. A more thorough analysis of these mechanisms through which household income influences evacuation expenditures would be a logical extension to this study (e.g., does investment in hurricane mitigation at homes reduce evacuation expenditure?).

Evacuation expenditures are also found to be correlated with hurricane risks. The median household would spend $170–$182 on lodging, food and transportation when evacuating to a safer place. The median evacuation expenditure is approximately $194 when households receive a voluntary evacuation order and more than $300 when the evacuation order is mandatory. Whitehead (2003) estimated similar evacuation

expenditures of \$211–\$292. Household evacuation expenditures presented in this study can be considered a lower bound of household willingness to pay for risk aversion through hurricane evacuation. We hope that these estimates can provide inputs for designing more effective evacuation programs and planning (e.g., offering vouchers to assist poorer households for evacuation).

Understanding hurricane evacuation behavior is a part of the planning puzzle for building sustainable coastal communities. Reliable estimates of evacuation expenditures based on granular household survey data are largely missing and in some extent contribute to that puzzle.

As storm-induced losses and casualties are rising (Emanuel 2005; Chatterjee and Mozumder 2014; Mozumder et al. 2014), we need to move beyond the back of the envelope calculation for evacuation cost estimation, e.g., 'one million dollars a mile' (see Whitehead 2003). While our findings provide some reliable estimates on evacuation expenses at the household level, it does not give any estimates of evacuation cost from emergency management agency perspective and future research can focus in this area to provide more comprehensive estimates on the social cost of evacuation.

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