Economics of Hurricane Evacuation

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Economics: Supply and demand

- Producers supply.
- Consumers demand.
- Weather affects both.
- How?
What is the Value of a Forecast?

- Not all weather impacts can be avoided.

- Weather information has economic value when it can affect human behavior.

- Are better weather forecasts a worthwhile public investment?
Economics of Storm Risk

- Decision makers maximize well-being under conditions of scarcity. Some examples:
  - Should I evacuate a storm?
  - Should I buy storm shutters for my windows?
  - Should I buy insurance?
  - Should I re-build my home?
- What should be our research priorities?
Evacuation as a Travel Cost Problem

- If it’s cheaper, you’re more likely to do it.
- Biggest cost may be taking time off work.
- Much depends on geography.
- People at risk, pets.
Evacuation in FL in 2005  
Co-authors: Daniel Solis, Michael Thomas  

- Studying the determinants of household evacuation can help to target public resources more efficiently by focusing on those individuals with higher risk and on those with lower probabilities to evacuate.

- Previous studies have been conducted, using data for a single event within specific geographical areas.

- By doing so, they miss a time and space component and overlook the possibility that households may learn from their own experience.

- This study constitutes a natural extension of previous studies by comparing two distinct regions and four separate hurricane events during the 2005 season.
Conceptual Framework

- Individuals make choices under the uncertainty of future environmental threat by maximizing their expected utilities, and that they might be willing to sacrifice their wealth in order to reduce those threats.

- Individual’s response is affected by four major elements:
  - Prior experience with the specific environmental hazard;
  - Individual’s wealth;
  - Intrinsic characteristics; and
  - Interaction with society.
Evacuation

- A hidden cost.
- Depends on storm intensity, behavior & population.
- Traffic, warnings, pets.
- Million $ a mile: An over-estimate would mean too few evacuation orders.
Empirical Model

Based on the theory and previous studies we estimated the following evacuation model using a **Probit** procedure:

\[
E_i = f(R_i, W_i, I_i, S_i, O_i)
\]

- **E**: Evacuation choice
- **R**: Individual’s perception of risk and their previous hurricane experience;
- **W**: Wealth and/or income;
- **I**: Household demographics;
- **S**: Social interaction and sources of information; and
- **O**: Other variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
</tr>
<tr>
<td>EVACUATION</td>
<td>Dummy variable equal 1 if the household evacuated their house during the studied storm, 0 otherwise.</td>
</tr>
<tr>
<td><strong>Prior experience and risk perception</strong></td>
<td></td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>Dummy variable equal 1 if the household has had previous experience with hurricanes, 0 otherwise.</td>
</tr>
<tr>
<td>MOBILE</td>
<td>Dummy variable equal 1 if the household lives in a mobile home, 0 otherwise.</td>
</tr>
<tr>
<td>FLOOD</td>
<td>Dummy variable equal 1 if the household lives in an area with flood risk, 0 otherwise.</td>
</tr>
<tr>
<td><strong>Wealth</strong></td>
<td></td>
</tr>
<tr>
<td>INCOME</td>
<td>Combined household income (US $).</td>
</tr>
<tr>
<td>OWN</td>
<td>Dummy variable equal 1 if the household owns their house, 0 otherwise.</td>
</tr>
<tr>
<td><strong>Household characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>FAMSIZE</td>
<td>Number of people living in the household.</td>
</tr>
<tr>
<td>KIDS</td>
<td>Number of kids in the household (less than 18 years of age).</td>
</tr>
<tr>
<td>PETS</td>
<td>Dummy variable equal 1 if the household owns a pet, 0 otherwise.</td>
</tr>
<tr>
<td><strong>Interaction with society</strong></td>
<td></td>
</tr>
<tr>
<td>FRIENDS</td>
<td>Dummy variable equal 1 if the decision to evacuate was influenced by friends</td>
</tr>
<tr>
<td>NOAA</td>
<td>Dummy variable equal 1 if the household uses the NOAA radio, 0 otherwise.</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
</tr>
<tr>
<td>EXPENSES</td>
<td>Total cost (US $) for the household evacuation preparation plan.</td>
</tr>
<tr>
<td>SFL</td>
<td>Dummy variable equal 1 if the household is located in South East Florida, 0 otherwise.</td>
</tr>
</tbody>
</table>
The data were gathered using a web-based survey.

A subsample was selected to include:

- households living in the study areas (NW and SE FL) during the 2005 hurricane season;
- who experienced Katrina, Wilma or Dennis; and
- answered variables key to our analysis.

The final dataset encompasses a total of 1,355 households.
The 2005 Atlantic hurricane season was the most active and harmful in recorded history (NHC, 2006):

- 2,300 deaths
- $130 billion in damages
2005 Season in Florida

3 Hurricane
4 Events (2 SE FL, 2 NW FL)
Results and Discussion

- The estimated models perform fairly well and the estimates are consistent across storms.
- The $H_0$ that all coefficients are simultaneously 0 is rejected consistently at the 1% level.
- Approximately 55.6% of all parameters are statistically different from 0 and their signs are generally consistent with expectations.
- In addition, the % of correctly predicted responses are high.

### Table 4. Probit estimates of evacuation decision.

<table>
<thead>
<tr>
<th>Variable</th>
<th>All</th>
<th>Katrina SE</th>
<th>Wilma</th>
<th>Dennis</th>
<th>Katrina NW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>ME</td>
<td>Coef.</td>
<td>ME</td>
<td>Coef.</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.183</td>
<td>0.059</td>
<td>-0.259</td>
<td>0.161</td>
<td>-0.411*</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>0.141*</td>
<td>0.071</td>
<td>0.409*</td>
<td>0.128</td>
<td>0.205*</td>
</tr>
<tr>
<td>MOBILE</td>
<td>0.881**</td>
<td>0.085</td>
<td>1.098***</td>
<td>0.347</td>
<td>1.031***</td>
</tr>
<tr>
<td>FLOOD</td>
<td>0.226***</td>
<td>0.011</td>
<td>0.557***</td>
<td>0.178</td>
<td>0.257*</td>
</tr>
<tr>
<td>INCOME</td>
<td>0.019</td>
<td>0.005</td>
<td>-0.013</td>
<td>0.005</td>
<td>0.057</td>
</tr>
<tr>
<td>OWN</td>
<td>-0.231***</td>
<td>0.011</td>
<td>-0.473**</td>
<td>0.037</td>
<td>-0.482**</td>
</tr>
<tr>
<td>FAMSIZE</td>
<td>-0.026</td>
<td>0.017</td>
<td>-0.099</td>
<td>0.014</td>
<td>-0.067</td>
</tr>
<tr>
<td>CHILDREN</td>
<td>0.047</td>
<td>0.005</td>
<td>0.113</td>
<td>0.004</td>
<td>0.165*</td>
</tr>
<tr>
<td>PET</td>
<td>-0.026**</td>
<td>0.006</td>
<td>-0.487**</td>
<td>0.009</td>
<td>-0.354**</td>
</tr>
<tr>
<td>FRIENDS</td>
<td>0.082</td>
<td>0.002</td>
<td>0.150</td>
<td>0.001</td>
<td>0.058</td>
</tr>
<tr>
<td>NOAA</td>
<td>-0.039</td>
<td>0.001</td>
<td>-0.108</td>
<td>0.000</td>
<td>-0.046</td>
</tr>
<tr>
<td>EXPENSES</td>
<td>-0.047**</td>
<td>0.006</td>
<td>-0.091*</td>
<td>0.006</td>
<td>-0.032</td>
</tr>
<tr>
<td>MAJOR</td>
<td>0.025</td>
<td>0.011</td>
<td>0.139</td>
<td>0.003</td>
<td>0.045</td>
</tr>
<tr>
<td>SFL</td>
<td>0.043**</td>
<td>0.017</td>
<td>0.199</td>
<td>0.034</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Log likelihood: $-906.35$, $-359.73$, $-235.10$, $-327.03$, $-218.22$

McFadden Pseudo $R^2$: 0.37, 0.33, 0.31, 0.32, 0.34


% of Correct: 74.13, 62.48, 61.61, 67.23, 69.13
Risk Perception

- On average, households living in *mobile homes* are 33% more likely to evacuate than their counterparts.
  - MOBILE display the highest ME in all models.
  - Baker (1991) indicates that emergency managers tend to target mobile home residents in their evacuation procedures.

- Households in *flooding areas* display, on average, an 9% higher probability to evacuate than those living in non-flooding zones.

- In addition, those households that have *experienced* the threat of a major hurricane in the past also display higher probabilities to evacuate.
Household Wealth

- **Home ownership** reduces the probability of evacuation in all estimated models.
  - Homeowners in SE FL show lower probabilities to evacuate than homeowners in NW FL.

- **INCOME** is not statistically different from 0.
  - Mixed results have been previously reported in the literature:
    - Whitehead (2000) → +
    - Smith (1999) → **not significant**

All among coastal residents in North Carolina
Household Composition

- The **number of children** is significant and (+)
  - One additional child in the household increases the probability to evacuate on approximately 5%.
- **Family size** is (-) but not significant.
- Households with **pets** have also lower rates of evacuation.
  - Owning a pet decreases the average probability to evacuate in 11.2%.
  - Whitehead (2000) suggested that establishing pet-friendly shelters could significantly increase the evacuation rates.
Household Evacuation Preparation

- The total cost for the household evacuation preparation plan is (-) and significant.
  - On average, an extra dollar expended in the evacuation preparation plan decreases the probability of evacuation in a 2%.
  - Households might consider storm preparation as a risk mitigation measure and feel more secure remaining behind with their home.
Regional differences in propensity to evacuate are clearly demonstrated:

- A likelihood ratio (LR) test rejects the null hypothesis for equality across geographical regions.
- This variation is confirmed by the statistically significance of the variable SFL in model ALL.
- The ME for SFL suggest that households living in SE FL are, approximately, 20% less likely to evacuate than people living in NW FL.
- This results agree with the idea that evacuation policies cannot be global and they should be developed based on the specific characteristic of the population (Fu, 2004).
Time

A set of LR tests is also used to test for changes in behavior within the hurricane season.

- Households in NW FL behaved in the same way for the two studied storms (no time effect).
- Households in SE FL did change their behavior through time (+ time effect).

These results agree with the pattern found for the variable EXPERIENCE.

- EXPERIENCE significant for households in SE FL, with evacuation less likely for Wilma than for Katrina.
- EXPERIENCE was not significant for NE FL residents.
Concluding Remarks

- The results suggest that households living in **risky environments**, with **children**, and with previous **hurricane experience** are more likely to evacuate.
- In contrast, **homeowners** and households with **pets** are less likely to evacuate.
- The more people **spend on storm preparation** the less likely they are to evacuate. Households might consider storm preparation as a risk mitigation measure.
- **Regional and time** differences are clearly demonstrated.
Key Social Science Questions

- What is the probability of large hurricane-related mortality?
- What costs do preparations and evacuations impose upon society?
- Can we demonstrate that forecasts reduce property damage as well as prevent loss of life?
- What is the optimum trade-off between warning lead time and size of the warning area?
- What weather elements should we be forecasting?
- How should we communicate forecasts?
- What mix or balance of improvements will yield the greatest benefits?
- What long-term plans should the federal government, the private sector, and the public develop?
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