An information entropy approach to salience for survey-driven simulation

David S. Dixon* Pallab Mozumder† William F. Vásquez‡

Interpreting a 2010 survey of Houston-area households subject to hurricane Ike in 2008, the difficulty in inferring ex-ante preferences from ex-post survey responses is exacerbated by many of the responses that rated most or all of the issues as "extremely important". From an information theoretical point of view, ranking all issues the same provides no more information than providing no answer at all. A response ranking only a few issues at a variety of levels of importance, on the other hand, provides insight about the individual respondent. In looking at the responses to ten related questions, information entropy - an information theoretical measure of information content - provides a measure of this variety in respondents. Assuming that higher information entropy implies higher salience, the group of respondents with highest information entropy are shown to be broadly representative of the total population surveyed while also providing clearer insights into motivations. A NetLogo agent-based model is calibrated based on the high information entropy survey responses.

1 Background

Hurricane Ike struck the Houston area at 2:10 AM on Saturday, September 13, 2008 (Berg, 2010). This hurricane, a Category 2 storm, was forecast to be especially dangerous not because of its winds, but because of high anticipated storm surge and subsequent flooding. A hurricane watch was issued on the afternoon of 10 September and a hurricane warning mid-morning on 11 September. A previously voluntary evacuation order for the west end of Galveston Island was made mandatory on Wednesday night, 10 September (TranStar, 2008). Mandatory evacuation orders were issued for the remainder of Galveston Island on 11 September, with the low-lying areas of Harris and adjacent counties following suit. The

* Visiting Faculty, Department of Economics, University of New Mexico, ddixon@unm.edu.
† Assistant Professor, Department of Earth and Environment, Department of Economics, International Hurricane Research Center, Florida International University, mozumder@fiu.edu.
‡ Associate Professor of Economics, Fairfield University, wvasquez@fairfield.edu.

highest storm surge at Galveston Island was measured at 11.48 feet (Berg, 2010). The storm left 36 dead, 134 missing, and 384 homes and buildings destroyed in the Houston-Galveston area(Vision, 2008).

2 Survey data

In 2010 the Florida International University Metropolitan Center completed 1,099 telephone interviews from a random probability sample of households located in Harris and Galveston counties in Texas with a response rate of 36 percent. A geocoded zip code area stratified sampling frame was used to oversample areas of higher storm surge risk. 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.

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, and about the type of evacuation order they received (i.e. voluntary or mandatory). In addition, respondents reported how important hurricane effects (e.g. surge), crime, and pets were for them in deciding whether to evacuate or stay at home when facing a hurricane like Ike. Finally, the survey garnered information about socioeconomic characteristics of respondents.

Of the households surveyed, 1,093 households responded to a question about the decision to evacuate, with 551 responding that they evacuated. Of those, however, on a subsequent question on timing, 41 responded "do not remember" or "did not evacuate". The cumulative distribution function (CDF) in Figure 1 is calculated from the 46.6 percent of the responses that included an evacuation day and period (AM or PM). A widespread evacuation order was issued early Thursday morning and more than fifty percent of the respondents had not evacuated by the time the hurricane struck very early Saturday morning.

A group of survey questions asked respondents to rate, in terms of making the decision to evacuate, the issues shown on the left of Figure 2. Although 75 percent of the respondents answered these questions, the responses are difficult to interpret because the majority of respondents rated all issues as extremely important or very important, and the relative rankings of the issues is consistent irrespective of whether the household evacuated, and whether or not they were subject to an evacuation order (Figure 2). Interpretation

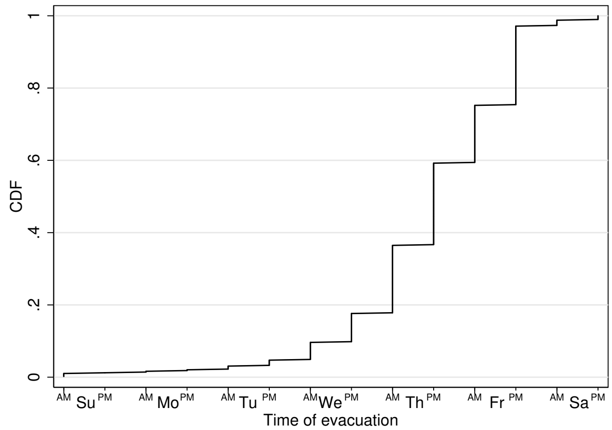

Figure 1: Cumulative distribution (CDF) as a function of time for evacuating households from a survey of 1093 households. Although 551 said they evacuated, on a subsequent question on timing, 41 of those responded "do not remember" or "did not evacuate". Thus, this represents evacuation by 46.6 percent of the respondents. A widespread evacuation order was issued early Thursday morning and the hurricane struck late Friday night.

not withstanding, the responses to a few of these issues are significant in one or more regressions: TIMELEFT, FLOODING, LOOTING, TOGETHER, and PETS.

3 Information Entropy

If we consider the survey responses as information about the respondents rather than a statement of their preference, responses in which all the issues were ranked as extremely important provide as little information as no response at all. In information theory, a metric of relative information is information entropy (Shannon and Weaver, 1948),

$$H_k = -\sum_{j=1}^{N} p_{jk} \ln p_{jk}$$

where

$$\begin{aligned} H_k &= \text{information entropy for respondent } k \\ N &= \text{the number of issue score values} \\ p_{jk} &= \text{probability mass function for issue score value } j \text{and respondent } k \end{aligned}$$

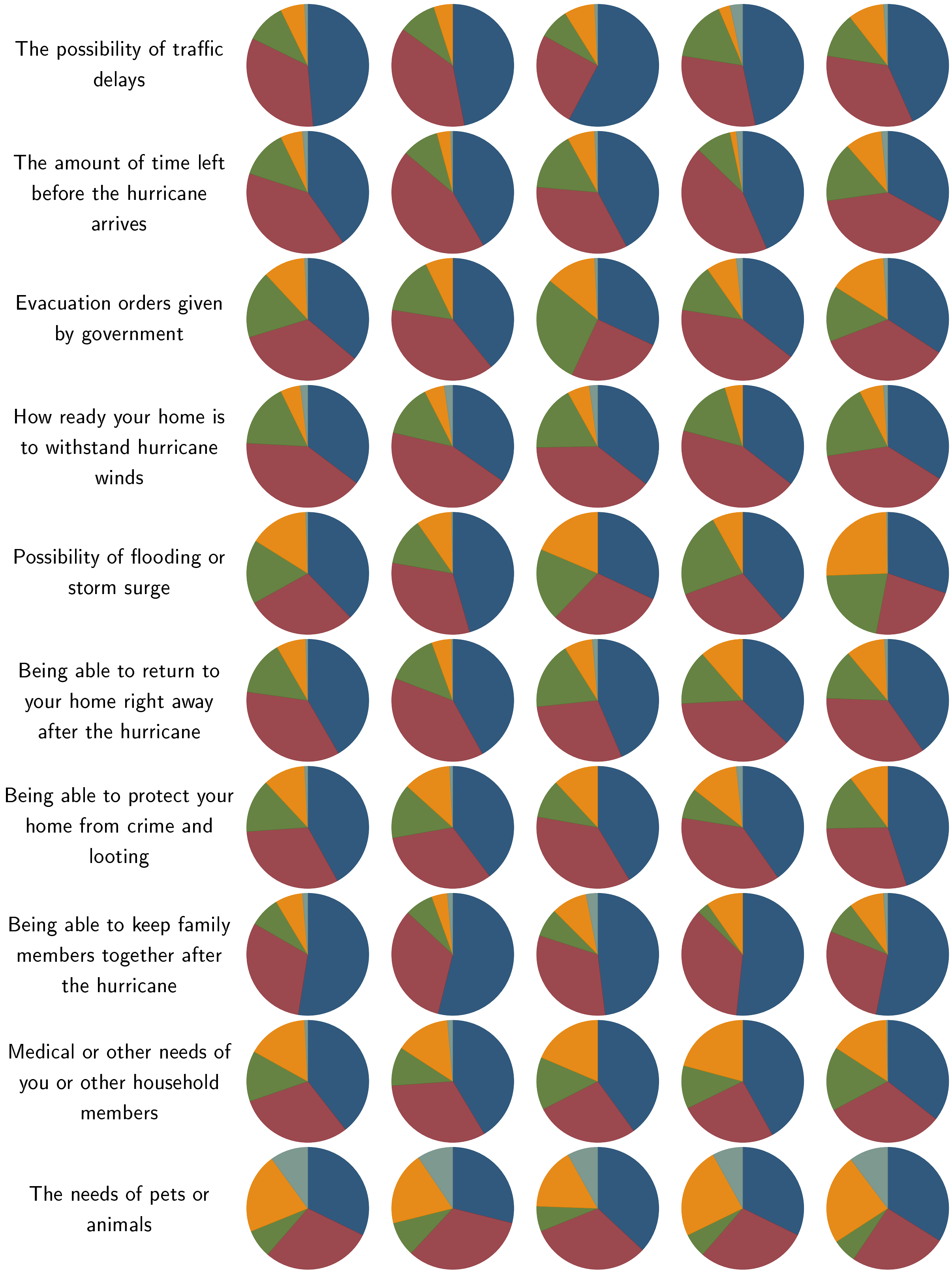

Figure 2: Importance (see legend in next figure).

Column headings

Survey question	All respondents	Evacuation order Evacuated	Evacuation order Did not evacuate	No evacuation order Evacuated	No evacuation order Did not evacuate
	Numbers of observations				
The possibility of traffic delays	819	308	135	62	254
The amount of time left before the hurricane arrives	820	309	135	62	254
Evacuation orders given by government	819	308	135	62	254
How ready your home is to withstand hurricane winds	820	309	135	62	254
Possibility of flooding or storm surge	820	309	135	62	254
Being able to return to your home right away after the hurricane	820	309	135	62	254
Being able to protect your home from crime and looting	821	310	135	62	254
Being able to keep family members together after the hurricane	819	308	135	62	254
Medical or other needs of you or other household members	820	309	135	62	254
The needs of pets or animals	819	308	135	62	254

Chart legend

Extremely important
Very important
Somewhat important
Not at all important
No answer

Figure 3: Legend for the importance charts.

Assuming that all issues have equal weight, and that the specific values (from *extremely important* to *not important*) are equally probable, the probability mass function can be expressed

$$p_{jk} = \frac{\sum_{i=1}^{N_k} \delta(x_{ik}, X_j)}{N_k}$$

where

$$\begin{aligned} N_k &= \text{the number of issues for which respondent } k \text{gave scores} \\ x_{ik} &= \text{score on issue } i \text{given by respondent } k \\ X_j &= \text{issue score value } j \\ \delta(x_{ik}, X_j) &= 1 \text{ if } x_{ik} = X_j, \text{ 0 otherwise} \end{aligned}$$

The higher the information entropy, the more information about the respondent contained in the responses. If we compute the information entropy for the responses to the issues-related questions, the respondents fall into the quartiles show in Table 1.

Table 1: Information entropy of responses to the ten issue-related survey questions. Statistics of information entropy showing the mean, standard deviation, and number of respondents in quartiles.

Summary for variables: entropy
by categories of: entClustNo

entClustNo	mean	sd	N
1	.2665148	.1997639	195
2	.705656	.0822766	206
3	.9673461	.049981	213
4	1.214324	.0931159	207
Total	.7974974	.3667116	821

Respondents in the highest entropy quartile tend to focus on one or only a few concerns, making it possible to isolate individual behavior rules. The results of a stepwise probit regression of the highest entropy (highest information) quartile shows that, for this group of respondents, 51 percent of them evacuated, and the most significant predictor is the order to evacuate (EVACUATD). The other significant predictors include if the respondent is Hispanic (HISPANIC), the propensity of damage less than one-third home value (LOWDMGLK), the influence of neighbors (NEIGINFL), and the issues of time left before the hurricane (TIMELEFT), keeping the family together (TOGETHER), and crime and looting after the hurricane (LOOTING). Hispanics are more likely to evacuate than non-Hispanics, neighbors tend to be an influence against evacuation, and increasing propensity of damage is an influence in favor of evacuation. For the issues, increasing concern about the time left is an influence in favor of evacuating, as is increasing concern with keeping the family together. Increasing concern with crime and looting is an influence against evacuation.

The respondents' ex-post estimate of the likelihood of damage and the concern variables, however, don't provide a priori information to predict propensity to evacuate. If respondents expressing specific concerns also have unique characteristics, it may be possible to formulate behavior rules based on a priori characteristics. The results of ten step-wise regressions of the concern variables are shown in the appendix. The signs of the coefficients are effectively inverted, since increasing values of the concern variables represent lower levels of concern. For all but the TRAFFIC variable, experience with hurricane Rita (HOUSRITA) reduced the level of concern. Previous preparation of the home, in terms of storm-proofing windows (WINDPREP) or elevating the structure (PILINGS), tended to increase the propensity to evacuate for those concerned about the time left or flooding, but lowered propensity if the respondent was concerned about crime or being able to return home. African-Americans (AFRIAMER) and Hispanics (HISPANIC) had higher levels of concern in several areas, yet lower with regard to pets and domestic animals (PETS). A larger household (NUMBINHH) increases the concern about the time left to evacuate (TIMELEFT), flooding (FLOODING), looting and crime (LOOTING), and keeping the family together (TOGETHER). Level of education (EDUC_LVL) ranges from 1 (grade school) to 6 (post-graduate) and reduces propensity to evacuate for those concerned with pets and with keeping the family together. The type of home appears in a few regressions: condo dwellers were responsive to the evacuation order and less interested in pets, while those in single family dwellings (SNGFAM) tended to evacuate in order to keep the family together.

4 ABM model and results

Though developed separately, this work is effectively both an extension of and a departure from a hurricane-evacuation agent-based model (ABM) by Widener et al. (2012). The Widner, Horner, and Metcalf (WHM) approach is to regress survey data and from the significant parameters construct a utility function that is the decision rule for all agents in the ABM. From their survey data, the WHM econometric model of the evacuation decision finds three significant variables: a) whether the subject lives in the risk area, b) whether the subject owns a vehicle, and c) the subject's experience with previous hurricanes. In addition to the utility model, WHM develop network models in which agents are nodes in a network with one of three topologies, each with a fixed and constant degree n (numbers of connections) that is varied from one simulation to another. The topologies explored by WHM are: n random connections to agents within radius 800 meters; $n-1$ small world (Watts and Strogatz, 1998) connections to agents within radius 800 meters plus one connection to a random distant agent; a random network of degree n without radius constraint. Network connections are not considered in the utility model, and utility is not considered in the network models.

The limitations of this model are: 1) Utility models rely on bounded rationality informed by very large numbers of transactions among large numbers of agents. In reality, the decisions of individuals are not necessarily rational or even transitive. Decision rules can capture this; 2) Human agents are not homogeneous. The relevant subsets of criteria to evacuate may be different between different groups of agents; 3) Real households exist within multiple networks simultaneously and not all networks have the same degree.

In our model the agents have a propensity for evacuation computed from seven propensity rules with different rules applying to different agents depending on characteristics. The rules, shown in Table 2, are based on the regressions discussed in the preceding section. A specific rule applies to an agent if that agent is subject to triggering variables. For example, the evacuation order rule only applies to the agents in the evacuation zone and only after the time that the order is issued. The other propensity rules only apply to agents for whom the survey data indicates they expressed some level of concern via the relevant concern variable. An agent reaches the point of making the decision to evacuate based on the propensity, then the decision on when to evacuate is influenced by the number of network neighbors who have already evacuated. Only two of the propensity rules are dynamic: the evacuation order rule only applies once the evacuation order is in effect, and the strength of the time left rule is attenuated linearly as landfall approaches. The neighbor rules are dynamic in that the payoff changes as the number of evacuating agents increases.

The agents have state variables taken from the survey data plus a state called *contrarian*. The contrarian state represents an agent's neighbor-based strategy, discussed in the next paragraph. The agents are on a network composed from three sub-networks: a dense network of all immediate neighbors, a random network of other agents in the neighborhood, and a random network of associations with agents drawn from the total set of agents. The radius of immediate neighbors, all of whom are included in an agent's network, is configurable. The other two networks, neighborhood and association, are random networks, so that the degree of each agent's network is stochastic, and the mean degree (average number of connections over all agents) is configurable. Also, the topology of the random networks is configurable, choosing between i) a Bernoulli random network (Erdős and Rényi, 1959), ii) a preferential attachment network (Wilensky, 2005) (a power-law distribution with exponent two and mean degree two), or iii) a truncated preferential attachment network (the power-law exponent is still two, but the mean degree can be greater than two).

In a game-theoretical network, neighbor-based decisions can reflect either strategic substitutes or strategic complements (Galeotti et al., 2010). Outcomes in these games are shown to be sensitive to network structure (Dixon, 2011). The decision threshold in the

Table 2: The propensity rules. Each contribution variable is scaled to have a value from zero to one, and each rule is scaled by the number of contributing variables and its associated influence variable (see text).

Rule Name	Contribution to propensity to evacuate
Evacuation order rule	-experience + AFRIAMER + HISPANIC + CONDO
Time left rule	-experience + preparation + AFRIAMER + NUMBINHH
Flooding rule	-experience + preparation + AFRIAMER + NUMBINHH
Return rule	experience - preparation - HISPANIC - AFRIAMER
Looting rule	experience - AFRIAMER - preparation - NUMBINHH
Family rule	-experience + SNGFAM - EDUC_LVL + NUMBINHH
Pets rule	experience + CONDO + EDUC_LVL + AFRIAMER + HISPANIC

experience is true if respondent experienced hurricane Rita in 2005.
preparation is true if respondent's home had undergone specific storm-proofing.

WHM model is equivalent to a strategic complement (do the same as the neighbors), whereas the survey data suggests that, for some respondents, the decision to evacuate reflects a strategic substitute (do the opposite of the neighbors). Differentiating between these two classes of behavior may be helpful in deciding an effective approach to increasing evacuation participation.

Our ABM is implemented in NetLogo (Wilensky, 1999), and the model interface is shown in Figure 4. Each agent - called a *turtle* in NetLogo - occupies a *patch*, which is a unit of space, equivalent in this model to an agent's home. All turtles exist on three simultaneous networks: a network of all immediate neighbors, a neighborhood network made up of a fraction of neighbors in the broader neighborhood, and an association network made up of turtles elsewhere in the model. The model has global attributes that include the number of turtles (records read from file), the range (in patches) at which a neighbor is considered immediate, the range (in patches) of the broader neighborhood, the topology of the neighborhood network, and the probability of a neighbor being on a turtle's network. Other model attributes are the percent of patches subject to evacuation order, the time (*tick*) when the evacuation order starts, the tick at which the hurricane makes landfall, percent contrarian, and the propensity threshold at which the neighbor rule is activated. Attributes for the association network include topology and the mean number of associates for each turtle. Because the networks are constructed stochastically, turtles have a varying number of connections on their networks, resulting in a distribution of degree (the number of network connections) across all turtles. This distribution is shown in the model interface in Figure 4.

For the purpose of assessing the global strengths of the seven rules, there are slid-

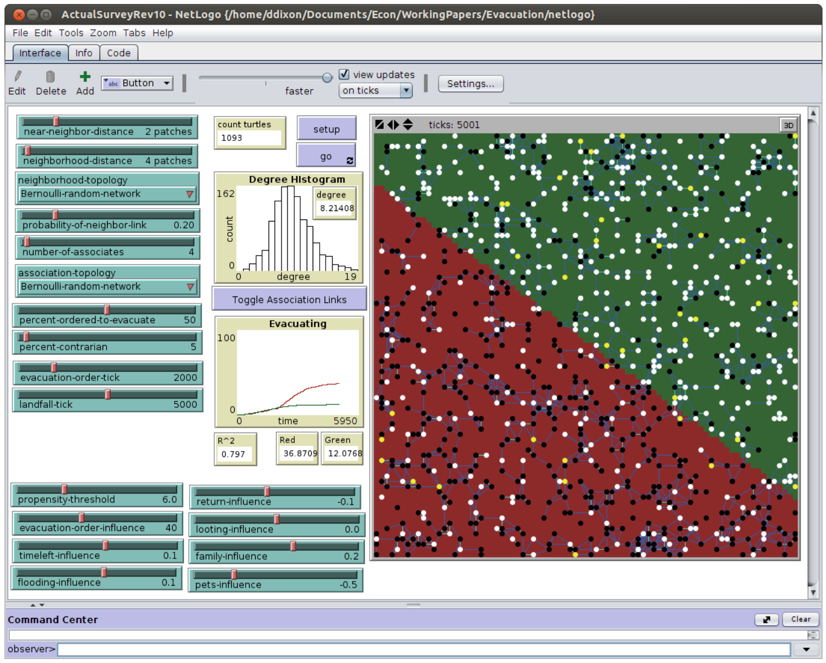

Figure 4: Screen shot of the ABM.

ers for rule multipliers: evacuation-order-influence, timeleft-influence, flooding-influence, return-influence, looting-influence, family-influence, and pets-influence. The sensitivity of outcome to these multipliers is determined using the NetLogo BehaviorSpace mechanism. For a total of 1000 Monte Carlo samples, the value for each multiplier is drawn from a uniform distribution over its domain. Each simulation is run to completion (5500 ticks). R-squared is computed from the difference between the simulation results and the survey data. The outcome variable is the half-day on which the household evacuated (the survey data plotted in Figure 1). The samples representing the top five percent of R-squared, with values ranging from 0.819 to 0.830, are summarized in Table 3. Note that the t-test indicates significance only for the evacuation order rule and the pets rule. That is, only these two rules have an apparent global weight across the population.

Figure 5 shows the rate of evacuation for those turtles subject to the evacuation order (red plot) and those not subject to the order (green plot). Compare the sum of these (black plot) with the survey data in Figure 1. Note that a few of each group evacuate prior to announcement of the evacuation order at tick 2000. After this time, the effect of the evacuation order on the propensity pushes the majority of affected turtles into the evacuation decision, with their evacuations timed stochastically until landfall at tick 5000. The slow increase in the slope of the green plot is the result of influence from neighbors and associates on both the green and the red sides who have evacuated (strategic complement payoff).

To explore the stochasticity of this simulation, the NetLogo BehaviorSpace tool was

Table 3: Multiplier estimates.

Multiplier	Mean	Std. Dev.	t-test
evacOrderInfl	6.8087898279	5.8174533737	0.1236927379
timeleftInfl	0.2041116656	0.6036536238	0.7366830616
floodingInfl	0.0477955532	0.5619458532	0.9325583875
returnInfl	-0.1238730361	0.5312258432	0.8165710154
lootingInfl	-0.0277521305	0.6059921538	0.9636551197
familyInfl	0.1481304952	0.528471433	0.7804039056
petsInfl	-0.5387424824	0.3399829302	0.119358739

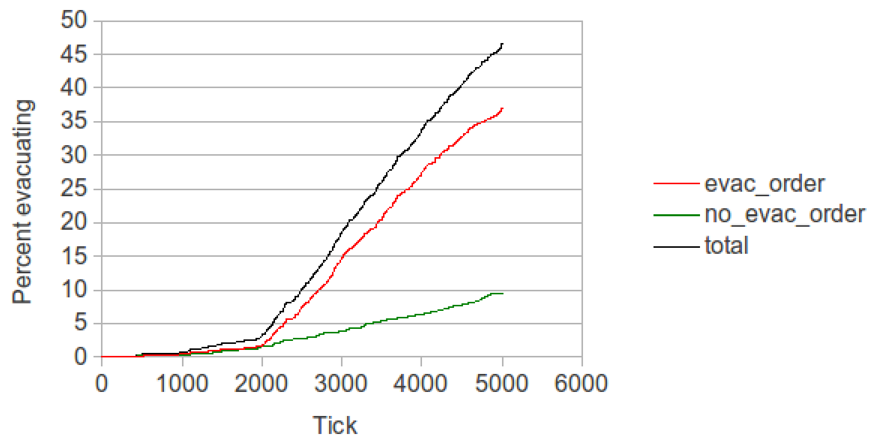

Figure 5: Simulation evacuation time series.

used to run one hundred Monte Carlo samples of the same model. The results for those evacuating under order (Red) and those evacuating without order (Green), in terms of mean and standard deviation, are

$$\begin{aligned}\text{Red (percent evacuating)} &= 36.37 \pm 1.54 \\ \text{Green (percent evacuating)} &= 9.618 \pm 1.004\end{aligned}$$

Note that, for Red, the standard deviation is only 4.2 percent of mean, while for Green, standard deviation is 10.4 percent of mean. For comparison, from the survey data, Red = 38.8 percent and Green = 9.00 percent.

5 Summary

An ABM is presented which is configured from survey data. An information content metric, information entropy, is considered a proxy for issue saliency. Focusing on the most salient responses to survey questions makes it possible to isolate some of the issues important in the decision to evacuate for a hurricane and the characteristics of the agents for which those issues are important. A set of seven simple behavior rules reproduce qualitatively the known evacuation trend shown in Figure 1. Only two rules appear to have similar weight across all agents. Results from ABM simulations are consistent with the known outcomes from the survey participants. A statistical ensemble using NetLogo BehaviorSpace illustrates the dynamics of outcome convergence.

References

Berg, R. (2010). National hurricane center tropical cyclone report on hurricane ike (al092008), updated may 3, 2010. *Published on the Web at http://www.nhc.noaa.gov/pdf/TCR-AL092008_Ike$_3$May2010.pdf*.

Dixon, D. S. (2011). An agent-based adaptation of friendship games: Observations on network topologies. In *Second Annual Conference*. Computational Social Sciences Society of the Americas.

Erdős, P. and A. Rényi (1959). On random graphs, I. *Publicationes Mathematicae (Debrecen) 6*, 290–297.

Galeotti, A., S. Goyal, M. Jackson, F. Vega-Redondo, and L. Yariv (2010). Network games. *Review of Economic Studies 77*(1), 218–244.

Shannon, C. E. and W. Weaver (1948). A mathematical theory of communication.

TranStar (2008). Transtar annual report for 2008.

Vision (2008). The vision, october 2008. *Houston-Galveston Area Council Department of Transportation*.

Watts, D. J. and S. H. Strogatz (1998). Collective dynamics of âsmall-worldânetworks. *nature 393*(6684), 440–442.

Widener, M., M. Horner, and S. Metcalf (2012). Simulating the effects of social networks on a population's hurricane evacuation participation. *Journal of Geographical Systems*, 1–17.

Wilensky, U. (1999). Netlogo. Accessed 31 August 2011.

Wilensky, U. (2005). Netlogo preferential attachment model. Accessed 31 August 2011.

Table 4: Appendix: Demographics of concerns.

Concern	TRAFFIC	TIMELEFT	EVORDERED	READINESS	FLOODING	RETURN	LOOTING	TOGETHER	MEDICAL	PETS
N	714	711	714	711	720	717	716	712	715	654
Adj R-squared	0.0166	0.018	0.0371	0.0171	0.0201	0.0362	0.0291	0.0552	0.026	0.0246
Constant	1.530858	1.85701	1.940977	1.897718	2.087606	1.775015	1.876017	1.773588	1.42732	1.530178
gini_coeff	0.8875211									
AFRIAMER		-0.1666671*	-0.3483195		-0.1902406*	-0.2696306	-0.2382858		-0.1879382*	0.5029133
HISPANIC			-0.3766566			-0.1937068				0.2516173*
EDUC_LVL	-0.0518007							0.0536457	0.1100306	0.0745136
HOUSRITA		0.2134811	0.267604	0.1743915*	0.3080434	0.3041939	0.3504435	0.2663657	0.2240018*	0.2432152*
WINDPREP		-0.1446083		-0.2153853	-0.1928798	-0.2155691				
PILINGS							-0.1887843			
NUMBINHH		-0.0415163*			-0.048188*		-0.0616731	-0.1054384		
APRTMNT	0.3015777									
CONDO										0.6440654*
DUPLEX	0.790515									
SNGFAM								-0.2913807		

All coefficients fit at 5% significance except those marked with an asterisk (*), which are 10% .

ODD

Purpose

The purpose of this model is to interpret survey data about hurricane evacuation in a way that leads to insight into specific behaviors.

Entities, state variables, and scales

There is only one entity in this model: the survey respondent, which represents a household faced with the decision to evacuate ahead of an impending hurricane. Each entity has the state variables in Table 5, all but *contrarian?* come from survey data. These variables take on actual survey values, the descriptive statistics for which are shown in Table 6. The state variable *contrarian?* is assigned stochastically in simulation. Environmental state variables are shown in Table 7.

Table 5: Survey data variable descriptions.

Variable	**Description**
HISPANIC	One if the respondent self-identifies as Hispanic
AFRIAMER	One if the respondent self-identifies as African-American
departed	The half-day the respondent evacuated, 7 if never evacuated
HOUSRITA	One if the respondent was in Houston for hurricane Rita
WINDPREP	One if the respondent's home had storm-proof window preparations
PILINGS	One if the respondent's home was elevated for storm-proofing
NEIGINFL	One if the respondent said the neighbor's were an influence
SNGFAM	One if the respondent has a single-family home
CONDO	One if the respondent has a condominium
NUMBINHH	The number of people in the household (1 to 11)
EDUC_LVL	The respondent's education level (1 to 6)
EVACORDR	One if the respondent was subject to the evacuation order
TIMELEFT	Level of concern expressed about the time left to evacuate
FLOODING	Level of concern expressed about flooding
RETURN	Level of concern expressed about being able to return home
LOOTING	Level of concern expressed about crime and looting
TOGETHER	Level of concern expressed about keeping the family together
PETS	Level of concern expressed about pets or livestock
contrarian?	True if the agent has a contrarian payoff

Table 6: Descriptive statistics of state variables.

Variable	Mean	Std. Dev.	N
HISPANIC	0.167	0.373	1020
AFRIAMER	0.151	0.358	1026
departed	4.461	1.02	488
HOUSRITA	0.853	0.355	1065
WINDPREP	0.513	0.5	1048
PILINGS	0.21	0.408	1037
NEIGINFL	0.129	0.336	1059
SNGFAM	0.883	0.322	1047
CONDO	0.022	0.147	1047
NUMBINHH	2.65	1.562	1054
EDUC_LVL	4.231	1.334	1011

Process overview and scheduling

There is a setup phase and a run phase. In the setup phase, the user-specified number of agents is instantiated by reading survey data from a comma-delimited file. Each agent is given a true value for a *contrarian* state with uniform probability *percent-contrarian*. For each agent, a network is constructed from all immediate neighbors (those with *near-neighbor-distance* radius). To this are added neighbors, with probability *probability-of-neighbor-link,* within *neighborhood-distance* radius . This network is constructed to have the topology specified by *neighborhood-topology*. Additionally, each agent is also on a network of *number-of-associates* agents selected at random from elsewhere in the model. This network is constructed to have the topology specified by *associate-topology*.

At the beginning of the run phase, each agent computes the constant part of the propensity to evacuate. At each tick, an agent is selected at random to update the propensity to evacuate. This is computed from the constant part plus the dynamic part, which depends on the specific tick and the rules in effect for that agent. At time *evacuation-order-tick*, all agents begin adding the evacuation order part of the dynamic propensity to evacuate. This computation continues until time *landfall-tick*, after which time no further state changes occur.

Design concepts

The general principle is the reproduction of human behaviors in a way that reproduces known characteristics of a population. At this point, the emergent property is the relative ratio of agents who evacuate even though they are not subject to an evacuation order. The agents in this model have no adaptive or learning capabilities. These agents do not optimize and therefore have no objectives. The predictive goal of the model is to identify the

Table 7: Environmental variable descriptions.

Variable	**Description**
`near-neighbor-distance`	The distance (in patches) within which another agent is considered a near neighbor
`neighborhood-distance`	The distance (in patches) within which another agent is considered within the same neighborhood
`neighborhood-topology`	The topology of the neighborhood network
`probability-of-neighbor-link`	Neighbors within neighborhood-distance join a neighborhood network with this probability
`number-of-associates`	The degree of an agents associates network
`associate-topology`	The topology of the association network
`precent-ordered-to-evacuate`	The percent of agents in the model for whom an evacuation order will apply
`percent-contrarian`	The percent of agents in the model who will tend to do the opposite of their neighbors
`evacuation-order-tick`	The simulation time at which the evacuation order will be issued
`landfall-tick`	The simulation time at which the hurricane will make landfall
`propensity-threshold`	The value of propensity-to-evacuate at which an agent will choose to evacuate
`evacuation-order-influence`	The multiplier on the evacuation order rule
`timeleft-influence`	The multiplier on the time left rule
`flooding-influence`	The multiplier on the flooding rule
`return-influence`	The multiplier on the return rule
`looting-influence`	The multiplier on the looting rule
`family-influence`	The multiplier on the family rule
`pets-influence`	The multiplier on the pets rule

motivators for evacuation or, more importantly, non-evacuation, in the face of a hurricane. The networks on which these agents live are entirely ad hoc, but it is a goal of this research to assess the sensitivity of outcomes to these global parameters. The only interaction between these agents is the influence that neighbors have on the decision to evacuate. The state variables come from survey data. There is no specific aggregation or collective behavior of these agents. The principle data collected are the trends and totals of the percent evacuation amongst both those subject to and those not subject to evacuation orders, and the R-squared fit of the actual time of evacuation to the survey-data time of evacuation.

Initialization

Agents are initialized from survey data in a comma-delimited file.

Input Data

The input data for initialization of state variables come from a 2010 survey by the Florida International University Metropolitan Center.

Submodels

There are no submodels.