

Risk Perception and Estimating Threat Probability Using Random Utility Models of Terrorist Objectives and Motivations

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1. Overview

This research project has two ongoing primary objectives: (1) Develop methods to estimate the likelihood of terrorism events (attack modes), and (2) Develop methods to predict both immediate and long-term public response to various terrorism events.

During Year 4 we made progress on both of these objectives by focusing on the decisions faced by terrorist leaders planning attacks, and on the decisions faced by U. S. residents following an attack directed toward the United States. In each case, we developed methods to identify the motivations and beliefs upon which decisions for future action would be based. Research progress and accomplishments made throughout Year 4 are described in the subsequent section.

2. Research Accomplishments

2.1. Estimating Likelihood of Terrorism Events

During Year 4 additional research was conducted to validate the methodology developed during Year 3 for estimating terrorist attack mode probabilities. The original model was developed under the assumption that uncertainties in the consequence matrix are independent of one another. We conducted a comprehensive sensitivity analysis varying the correlations among attribute distributions for each alternative. The sensitivity analyses allowed for both weak and strong correlations across attributes, as well as both positive and negative relationships (depending on the attributes). Results indicated that probability of various attack modes is not greatly affected by the correlations among the attributes in the consequence matrix.

The original model also assumed that the additive utility function was suitable for delineating the preference structures. However, our complete knowledge of a terrorist’s fundamental objectives is in fact limited. We modified the model design by exploring the value of a multiplicative approach. In doing so, we accounted for the possibility of violations of value independence. We performed sensitivity for deviations from additivity, assuming a multiplicative form with a single parameter capturing the degree of non-additivity. Multiplicative utility functions are useful in representing multi-attribute multi-attribute risk aversion and multi-attribute risk seeking, as well as both substitution and complementing effects. Our results suggest that risk profiles for the attack mode options do depend on the degree of value independence among the attributes, and that multi-attribute risk attitudes are an important component of terrorist utility functions. A paper reporting the model, including both sensitivity analyses described above, is near completion and will be submitted for publication in a refereed journal during early 2009.

Lastly, when reflecting upon some of the assumptions made relative to the multi-attribute utility models, we realized the importance of accounting for perspective taking in the study of terrorist values. Given the

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uncertainties surrounding our knowledge of terrorism, certain analytical approaches have been adopted that do not necessarily lead to the best estimate of the threat. For example, the government traditionally has applied maxi-min strategies and zero sum game assumptions. These approaches by design project the government's values upon the terrorist, and consequently do not produce a good assessment of the threat. As a result, we explored variation in the objectives hierarchy representing different proxy terrorists, as well as variations across models for different stakeholders - proxy terrorists and government officials. Our hypothesis is that given the stakeholder under consideration, the attack preferences will vary. We hope that through ongoing research into the assumptions and preferences input into these models, we might formulate additional incite into terrorist strategies and assist in the allocation of counterterrorism resources. Draft models for comparison have been developed using research conducted by various CREATE researchers, including John and Rosoff, as well as related work conducted by both Keeneys (Ralph and Gregory). This work will continue in Year 5 and will result in a separate paper to be submitted for publication by the end of Year 5.

2.2. Risk Perception Studies

Following introduction of vignettes in Year 3 to study systematic differences in reactions to terrorist events, we continued to design and collect data using new vignettes describing terrorist attack scenarios. In one such study, we designed a 2 by 2 factorial experiment to investigate the effects of statements by government following a terrorist dirty bomb attack and the effects of social norms. The vignettes include dirty bomb attacks at 4 separate local public landmarks in the Los Angeles area. The vignettes are varied only in government advisory (evacuate immediately vs. continue business as usual) and the report of the on-site public response (wide-spread panic to leave the site vs. orderly behavior near the site).

Over 200 subjects responded to each of the 4 vignettes in terms of both emotional and cognitive reactions, as well as behavioral intentions for the future. Half of the subjects responded to open ended questions about behavioral intentions that allow use of the NANOVA analysis procedure, developed by CREATE researcher David Weiss as part of another CREATE research project; the other half of the subjects provided reactions using rating scales, allowing for more traditional Functional Measurement analysis employing standard ANOVA procedures. A repeated measures design was used, with all subjects responding to all 4 vignettes. A Latin Squares design was used to systematically vary the order of the vignettes, and results were obtained using both a repeated measures analysis and a between-groups analysis (on first vignette in sequence only). The results of these studies have been reported at a research conference and a paper describing the study and results is currently being drafted and will be submitted for publication (e.g., Risk Analysis) in early 2009.

Another study employing vignettes was also designed during Year 4 involving terrorist attacks on US passenger airplanes with MANPADs. A 2 X 2 independent groups design using 4 new vignettes was developed to systematically investigate cognitive, emotional, and behavioral intentions following such an attack. In this study, subjects respond to only one vignette, that varies systematically in the government advisory regarding risks from future MANPAD attacks, and social norms as indicated by airline ticket purchases relative to available capacity. Subject responses include measures of intentions to fly relative to 4 different possible future events requiring travel (e.g., job interview, attend a wedding, etc.)

Several different designs were piloted, including one that includes personality measures to identify individual differences and potential moderating variables for the effects of government advisory related directly to risk level and social norms. Data collection has begun, and will continue into Year 5. We anticipate completing this study during Year 5, including data collection, data analysis, report writing, and submission to a refereed journal.

3. Collaborative Projects

As indicated above, this work was closely coordinated with the work of Prof. Weiss at California State University, Los Angeles.

4. Research Products

4.1. Presentations

- John, R., Rosoff, H., "Perspective Taking: Avoiding the Zero-Sum Trap," *Behavioral Economics and Terrorism*, CREATE, USC, Los Angeles, CA, August 15-16, 2008
- John, R., Rosoff, H., "Perspective Taking and Threat Assessment," *Conference on Human Behavior and Security*, MIT, Cambridge, MA, June 30-July 1, 2008
- John, R., Rosoff, H., "Probabilistic Project Management for a Terrorist Planning a Dirty Bomb Attack on a Major US Port," workshop at naval postgraduate school on critical infrastructure, Monterrey, CA, June 6-7, 2008
- John, R., Rosoff, H., "Random Utility Modeling for the Rational Terrorist," *3rd Annual Los Alamos National Laboratory (LANL) Risk Symposium*, Santa Fe, NM, March 11-13, 2008
- Rosoff, H. von Winterfeldt, D., "Risk and Economic Analysis: A Dirty Bomb Attack on the Ports of Los Angeles and Long Beach," *2008 Homeland Security S&T Stakeholders Conference West*, Los Angeles, CA, January 14-17, 2008
- John, R., Rosoff, H., "Who's Afraid of Osama bin Laden?" research paper presented at the *46th Annual Edwards Bayesian Conference*, Fullerton, CA, January 10-11, 2008
- John, R., Rosoff, H., "Osama is Ready to Hear This. Are You?" research paper presented at the *46th Annual Edwards Bayesian Conference*, Fullerton, CA, January 10-11, 2008
- John, R., Rosoff, H., "What Do We Know about Public Perception of Terrorism Risks?" paper presented at the *Annual Meeting for the Society for Risk Analysis (SRA)*, San Antonio, TX, December 2007
- John, R., Rosoff, H., "Monte Carlo Simulation to Construct a Random Utility Model of Terrorist Preferences for Attack Modes," paper presented at the *Annual Meeting for the Society for Risk Analysis (SRA)*, San Antonio, TX, December 9-12, 2007
- John, R., Rosoff, H., "Cognitive, Emotional, and Behavioral Reactions to Terrorism Events," Homeland Security sponsored paper presentation at the *Annual Meeting for the Institute for Operations Research and Management Science (INFORMS)*, Seattle, WA, November 4-7, 2007
- John, R., Rosoff, H., "Decision Analysis by Proxy for the Rational Terrorist," Decision Analysis Society sponsored paper presentation at the *Annual Meeting for the Institute for Operations Research and Management Science (INFORMS)*, Seattle, WA, November 4-7, 2007

5. Education and Outreach Products

Education and Outreach Initiatives (Please detail below)	#
# of students supported (funded by CREATE)	2
# of students involved (funded by CREATE + any other programs)	4

Funded by CREATE

- Heather Rosoff, Doctoral Candidate, 2009. University of Southern California (USC) School of Policy, Planning and Development
- Marcel Hovsepian, Master of Public Policy Candidate, 2009. USC School of Policy, Planning and Development

Summer Students

- Tarra Jackson, Doctoral Student, visiting scholar from Howard University
- Carlos Cintron, visiting DHS scholar from The University of Puerto Rico, Ponce