Impacts of Extreme Events, Phase 1:
Intercity Passenger Travel Behavior - The September 11th Experience

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OBJECTIVES OF THE PROJECT

The tragic events of September 11th, 2001 (9/11) have had a profound and unimaginable impact on activities in all of lower Manhattan, and the New York City metropolitan region. Profound, of course, because of the huge loss of life, and because of the continuing sense of trauma of the survivors. These events have also provided a monumental challenge to transportation and city planners because there are no guidelines in US planning/engineering literature on how to manage after such an event occurs.

The scale of the event was enormous: 13.4 million square feet of office space were lost in the World Trade Center (WTC), while 12.1 million square feet were rendered temporarily unusable in the adjacent properties (New York Times, 2002). Over 100,000 jobs were displaced. Tens of thousands of additional jobs have been lost or interrupted because they serve the WTC and its neighborhoods. Additional acts and threats of terror, such as the Anthrax attacks, have made New Yorkers cautious about where and how they travel to participate in activities.

The changing perception of the safety of the transportation modes is, in particular, impacting the way in which the traveling public makes choices concerning mode, place of work and residence. On September 10th, most travel analysts would say that reliability, travel time and cost were the primary determinants of mode choice. On September 12th, personal security became, and still remains for many New Yorkers, a key concern. As a result of 9/11, businesses and individuals are making choices that will impact whether or not: (a) they remain in their jobs in a new location, outside the impacted site; (b) they change jobs; (c) they change travel mode or its route; (d) they move from the New York region; among many other possibilities. While all of these choices are extremely complex, closely inter-related and changing over time, two dimensions of choice stand out. The first is the individual's overall response to the tragedy, and their personal relationship to it. The second is the individuals' sense of security as it applies to each mode available for their given trip. Travel choices will vary according to the individual and their personal response to the tragedy.

The main objective of this project is to assess the impacts of 9/11 upon passenger travel behavioral. This knowledge may assist transportation, and emergency response, agencies to speed up the process of recovery after an extreme event.

MAJOR RESEARCH AND EDUCATION ACTIVITIES

The unique nature of this research project necessitated the implementation of a research approach able to capture the most significant changes in passenger travel behavior that have taken place as a consequence of the tragic events of 9/11/01. To this effect, the research team decided to use behavioral models based on Random Utility Theory (RUT) to assess such behavioral changes. In this context, the random utility models provided the methodological

framework for the assessment of behavioral changes, while the transportation surveys conducted provide the data to be used in the analyses and model estimation processes.

The research approach was comprised of two major tasks. The first one is related to the definition of the choice experiment, the survey instrument, and the corresponding data collection process. The second tasks consisted of behavioral modeling.

The choice experiment and the survey instrument

In order to provide a decision context for the respondents, the project team selected a choice situation that involved a compulsory trip, supposedly a business trip to another city. A business trip was selected because its compulsory nature eliminates one choice dimension, i.e., the decision or not to travel. This, in turn, presents a fairly clear choice situation that minimizes misunderstandings on the part of the respondents. Another benefit of using a compulsory trip in the choice situation is that the behavioral changes identified could be interpreted as lower bounds of the impacts, because non-compulsory trips (because of their inherent elasticity) are likely to be more impacted than compulsory trips.

Another relevant decision concerning the choice situation involved the trip distance. Since for long trip distances, air transportation may be the only practical alternative, focusing on long distances would have made it more difficult to assess behavioral changes in intercity travel because the dimension of mode choice would not have been present (which is the anticipated consequence of the decision makers feeling "captive" of air transportation). For that reason, the project team decided to focus on the lower range of trip distances, for which the decision makers have different alternatives that effectively compete with each other. In this context, the behavioral changes would reveal themselves as components of the tradeoffs among alternatives captured by the systematic component of the utility functions.

The respondents were randomly assigned to three different trips: (a) New York-Washington, D.C, (b) New York-Boston, and (c) Boston-Washington, D.C. The percentages of respondents for each trip type were 43.47%, 28.80% and 27.71% respectively. The breakdown of responses according to trip type correlates fairly well with the breakdown from the American Travel Survey, ATS, (BTS, 1997).

The questionnaire was administered to an initial set of volunteers, graduate and undergraduate students at the City College of New York. The graduate students were asked to administer the questionnaire to three other individuals selected by them in order to maximize the variability in the socio-economic characteristics of the sample. The undergraduate students were only asked to respond to their questionnaires. Each volunteer filled out a consent form and one of four versions of the survey. The confidentiality of the responses was guaranteed, in accordance to National Science Foundation's human subject research guidelines. A total of 192 volunteers participated in the study. The questionnaires were administered during the period 3/14/02 and 4/4/02, approximately six months after 9/11.

Behavioral modeling

In terms of behavioral modeling, two different types of random utility models were estimated: Nested Logit and Covariance-Heterogeneity Nested Logit models. These two basic types were used in the estimation process using the variables gathered during the data collection process.

The estimated models are highly consistent among themselves in highlighting a set of fundamental conclusions about travel behavior in the aftermath of an extreme event.

The modeling results confirmed previously held assumptions about the factors determining intercity mode choice. Variables such as travel costs, time, income, gender and the like were found to be statistically significant explanatory variables in the mode choice process. These results are in complete agreement with the intercity mode choice literature (e.g., Forinash and Kopppelman, 1993; Bhat, 1997).

The research was successful in finding statistically significant linkages between changes in travel behavior and the impact of an extreme event, in this case 9/11. These linkages revealed themselves as additional terms in the utility functions estimated using Random Utility Theory. In all models estimated, the variable that measured the impact of the 9/11 events upon the individuals that participated in the survey, i.e., *Change*, and a psychometric scale of perceived stress level, i.e., *Stress*, were found to play a statistically significant role in the mode choice process. Interestingly, *Change* and *Stress* seem to have different mechanisms.

The variable *Change* was found to have significant interactions with the travel time. This, in turn, translates into the marginal disutility of travel time being modified by *Change*, as shown in Equations (8) to (19). The magnitude of this modification is clearly related to the transportation mode. In all cases, the contribution of the interaction term between *Change* and travel time is highest for air, followed by car and then train. This may be related to: (a) the fact that the terrorist attacks of 9/11 involved airplanes; and (b) the effect this had on the general public's perception about the safety of the air transportation system after 9/11. The modeling results clearly indicate that the utility functions of the train alternatives are minimally affected by the interaction terms between *Change* and travel time (in some cases, the interaction term drops out of the utility functions). The latter suggests that the users perceive the train alternatives as being less taxing to them, in utility terms, after an extreme event such as 9/11.

The perceived level of stress, i.e., *Stress*, was found to have a statistically significant impact in mode choice. However, the interpretation of the impact of *Stress* and its relation to 9/11 is obscured by the fact that the psychometric measured used (PSS4; Cohen and Williamson, 1988) provides a measure of overall stress level, not of the stress specifically produced by 9/11. In any case, *Stress* specifically impacted the utility function of air without interacting with any other variable or utility function. In general terms, the higher the stress level, the less likely the decision makers to choose the air alternative.

In spite of the numerous and significant limitations faced in this research, the authors are confident in the ability of this research to provide insights into the effects that extreme events have upon intercity travel behavior. This modest success should not obscure the fact that this paper is nothing more than a first step in the long march towards a better understanding of the impacts of extreme events on travel behavior.

Papers:

Holguín-Veras, J., R. Paaswell and A. Yali (2003) "Impacts of Extreme Events on Intercity Passenger Travel Behavior: The September 11th Experience" Chapter 15 in *Impacts of and Human Response to the September 11, 2001 Disasters: What Research Tells Us*. Special Publication #39. Boulder, CO: Natural Hazards Research and Applications Information Center, University of Colorado.

MAJOR FINDINGS

Participants reported that prior to 9/11 they were most likely to choose transportation mode based on convenience and cost, and the mode of preference by most was car. Indeed, trips by car were rated better on cost than air or train, and were rated as more secure than trains. While there were no other significant differences among the primary modes (air, train, car) on any of the other features assessed (cleanliness, comfort, and safety), these features may not be as important as cost when choosing mode, especially when one is paying for the trip oneself, as was the case for the majority of participants.

On average, participants reported that 9/11 impacted travel change "moderately" but it is important to note that the full range of the scale was endorsed by participants. The most frequently reported specific changes were that people became more conscious of security and more aware of other travelers. Participants also had average perceived stress levels that correspond to "almost never" on the response scale, which is comparable to the data from a national probability sample (Cohen and Williamson, 1988). Despite low levels of perceived stress, the general change measure was significantly associated with stress levels, such that those who reported a greater 9/11 impact on travel behavior also reported greater levels of perceived stress.

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The modeling results confirmed previously held assumptions about the factors determining intercity mode choice. Variables such as travel costs, time, income, gender and the like were found to be statistically significant explanatory variables in the mode choice process. These results are in complete agreement with the intercity mode choice literature (e.g., Forinash and Kopppelman, 1993; Bhat, 1997).

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OPPORTUNITIES FOR TRAINING AND DEVELOPMENT

As indicated in the proposal, the Principal Investigator is interested in the effective integration of research and education. As part of this guiding principle, the project team was structured as to ensure that Doctoral students work closely with Master students; while Master students work closely with undergraduate students. All of the students work under the supervision of the Principal Investigator.

In all, a total of two students (one Master, and two undergraduates) have been provided financial support. All of them are Hispanics.

Research, teaching skills and experience:

The Master student was in charge of the analyses of the responses and the preliminary estimation of behavioral modesl. Undergraduate students have benefited from their participation on this project in that they have had the opportunity to: (a) undertake data analyses; (b) develop a better understanding of behavioral analyses of passenger phenomena.

Both graduate and undergraduate students have had the opportunity to enhance their teaching and communication skills. Graduate students have played an active role as instructors of undergraduate and graduate courses; while undergraduate students have had the opportunity to teach and tutor High School students.

OUTREACH ACTIVITIES

The bulk of the outreach activities undertaken in this project are related to the coordination efforts with different stakeholder agencies. As part of the research project, the project team actively participated with staff of the New York Metropolitan Transportation Council (NYMTC), and the Port Authority of New York and New Jersey, in the definition of the survey instruments and in the process of data collection.

These outreach activities have significantly enhanced the relationship between the PI and the agencies.

PUBLICATIONS AND PRODUCTS

Publications:

Holguín-Veras, J., R. Paaswell and A. Yali (2003) "Impacts of Extreme Events on Intercity Passenger Travel Behavior: The September 11th Experience" Chapter 15 in *Impacts of and Human Response to the September 11, 2001 Disasters: What Research Tells Us*. Special Publication #39. Boulder, CO: Natural Hazards Research and Applications Information Center, University of Colorado.

Web sites:

http://www.rpi.edu/~holguj2/index.html

Other products (databases, physical collections, educational aids, software):
None.

CONTRIBUTIONS

To the principal discipline:

The main contributions of this project to the principal discipline are:

1. To develop an enhanced understanding of the impacts of extreme events upon passenger travel behavior;
2. To quantify the behavioral effects as part of the utility functions of discrete choice models;
3. To provide the behavioral foundations for the behavioral analyses in the aftermath of extreme events.

To other disciplines:

1. To develop a better understanding of the psychological impacts of extreme events, and how they are likely to affect the population of large metropolitan areas;
2. To provide empirical estimates of the impacts of 9/11 upon the New York population.

To the development of human resources:

1. This project included graduate, undergraduate and High School students as part of the experimental work. This experience provided these students with first hand exposure to transportation research and education.

To Contributions to Resources for Research and Education:

1. The success of this project in integrating research and education has the potential of significantly enhancing the experience of the students involved. This, in turn, may have the potential to help them understand the benefits of such integration.

Beyond Science and Engineering:

1. To develop a better understanding of the psychological impacts of extreme events, and how they are likely to affect the population of large metropolitan areas;
2. To provide empirical estimates of the impacts of 9/11 upon the New York population.