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Modeling Hurricane Evacuation Traffic: Development of a Time-Dependent Hurricane Evacuation Demand Model

Introduction

In general, transportation modeling for hurricane evacuation has followed procedures similar to those used in urban transportation planning. One of the most significant features of urban transportation planning, with respect to evacuation modeling, is that the forecast of traffic conditions is static. That is, traffic is forecasted for a period, such as a day or a peak period, and, within that period, traffic is assumed to flow uniformly. During evacuation, traffic conditions change regularly, and people make route changing decisions dynamically due to varying traffic conditions. The traditional static procedures do not give any information on the dynamics of the traffic.

One of the fastest growing research areas in travel demand modeling in the past 20 years has been dynamic traffic assignment (DTA). DTA seeks to assign traffic continuously or in very short time intervals and then keeps track of the vehicles both temporally and spatially. This makes it possible to know at every moment or in short periods of time which vehicle is traversing which link at what speed. This is a fundamental improvement from static assignment. Moreover, DTA can make the assignment responsive to varying road conditions, such as capacity changes due to incidents, road closures, or the reverse-laning of facilities at certain times during the evacuation process. Its application in hurricane evacuation can be especially valuable to improve planning capability. However, in order to be able to apply DTA, time-dependent O-D information is required, and current methods of estimating time-dependent evacuation demand are relatively crude. Therefore, the development of a time-dependent hurricane evacuation demand model is needed to provide an improved overall modeling process for hurricane evacuation.

Objective

The objective of this research is to develop alternative time-dependent travel demand models of hurricane evacuation travel and to compare the performance of these models with each other and with the state-of-the-practice models in current use. Specifically, the research is directed at addressing the following hypotheses:

- Time-dependent travel demand models that reproduce hurricane evacuation travel more accurately than conventional methods that use evacuation participation rates and response curves can be developed.
- Time-dependent travel demand models that are capable of reproducing hurricane evacuation travel at different locations and under different storm and policy conditions can be developed.

Scope

The research in this study explored different methodologies to develop time-dependent demand models for hurricane evacuation. Two survival analysis method models (the Cox Proportional Hazards

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model and the Piecewise Exponential model) and two sequential choice models (sequential logit model and complementary log-log model) were used in the study. Household survey data from several hurricanes were utilized in the modeling effort, including two revealed preference surveys and one stated preference survey. The models developed in this study were compared with the traditional models. The transferability of the developed models was also tested.

Research Approach

In this study, time-dependent travel demand models for hurricane evacuation were developed with two methodologies: survival analysis and sequential choice model. Using survival analysis, the time before evacuation from a pending hurricane is modeled considering those who do not evacuate; such involves censored observations. A Cox proportional hazards regression model with time-dependent variables and a Piecewise Exponential model was estimated. In the sequential choice model, the decision to evacuate in the face of an oncoming hurricane is considered as a series of binary choices over time. A sequential logit model and a sequential complementary log-log model were developed. Each model is capable of predicting the probability of a household evacuating at each time period before hurricane landfall as a function of the household's socio-economic characteristics, the characteristics of the hurricane (such as distance to the storm), and policy decisions (such as the issuing of evacuation orders).

Conclusions

1. It is possible to produce time-dependent travel demand models for hurricane evacuation that are more accurate than conventional models that use participation rates and response curves to estimate dynamic evacuation demand.

2. The sequential logit model performs better than survival analysis models in reproducing observed evacuation behavior.

3. The sequential logit model developed in this study has demonstrated that it can reproduce the evacuation behavior observed in different locations and under different storm conditions with reasonable accuracy; i.e., the sequential logit model appears transferable.

4. The sequential logit model developed in this study is easy to use and uses readily available and/or easy to obtain variables in the model, which are also the major variables proven to be important in hurricane evacuation.