A Process Model for Route Choice in Risky Traffic Networks

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Motivation

- Traveler's choice under risk is a key factor of network reliability
- Two different modeling paradigms
  - Econometric: "as-if"
  - Process: **actual decision process**

Priority Heuristic

(Brandstatter *et al.* , 2006)

A decision maker arrives at the final choice through a series of comparisons of outcomes and/or probabilities.

- **Priority Rule**. Go through reasons in the order: minimum outcome, probabilities of minimum outcome, maximum outcome.
- **Stopping Rule**. Stop examination if minimum outcomes differ by 1/10 (or more) of the highest maximum outcome; otherwise, stop examination if probabilities differ by 1/10 (or more)
- **Decision Rule**. Choose the prospect with the more attractive maximum outcome.

Certainty Effect Example

($4000, 0.8; 0, 0.2) vs $3000

- MinOutcome: 3000 - 0 > 1/10 * 4000, so pick the one with higher minimum outcome ($3000)

($4000, 0.2; 0, 0.8) vs ($3000, 0.25; 0, 0.75)

- MinOutcome: 0 - 0 < 1/10 * 4000, go to the next reason
- ProbabilityofMinOutcome: 0.8 - 0.75 < 0.1, go to the next reason
- MaxOutcome: pick the one with higher maximum outcome

($4000, 0.2; 0, 0.8)

Account for Violations of EU

- The Allias paradox
- The fourfold risk attitudes joinly determined by the domain (loss/ gain) and probability (high/low)
- The certainty effect
- The possibility effect
- Intransiviity

Probabilistic Priority Heuristic (PPH) Model

(*Amax*, 1 – *Apr*; *Amin*, *Apr*) vs
(*Bmax*, 1 – *Bpr*; *Bmin*, *Bpr*)

- Add a random noise to the difference between a reason (R = min, max, pr)
- If R is not the last reason
  - $P_R(A|\{A,B\}) = P(A_R-B_R > \delta_R * \text{MaxOutcome})$
  - $P_R(B|\{A,B\}) = P(B_R-A_R > \delta_R * \text{MaxOutcome})$
  - $P_R(A) + P_R(B) < 1$ when $\delta_R > 0$
- The probability of going to the next reason is
  - $1 - P_R(A) - P_R(B)$
- If R is the last reason

$P_R(A) = P(R_A > R_B)$ (similar to random utility model)

Likelihood of Observing Alternative A:

P(A)

$= P_{R1}(A) +$ **(reason 1)**

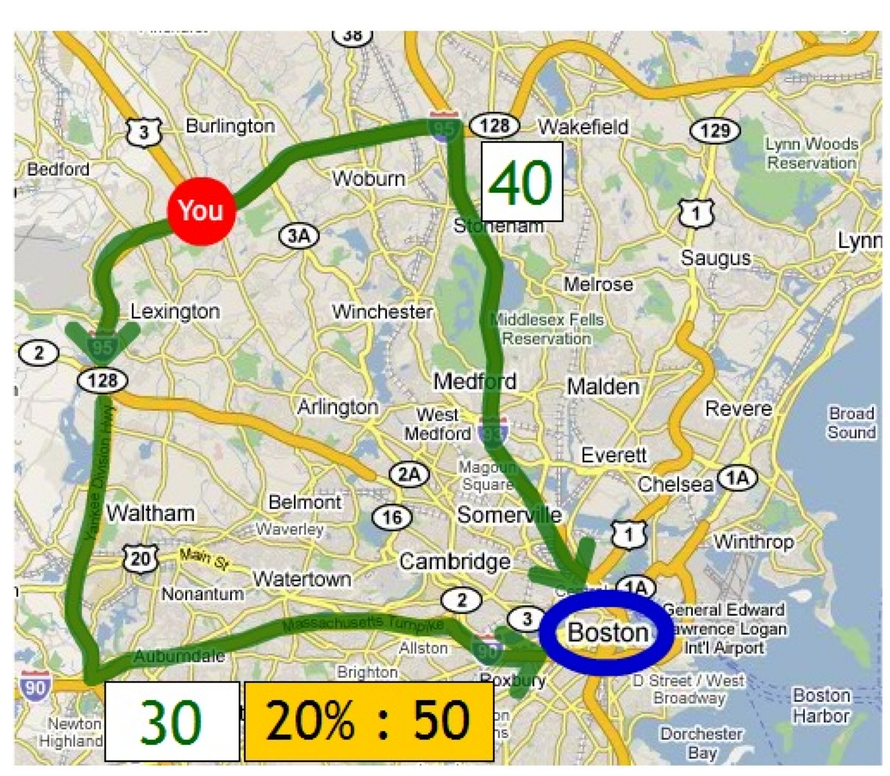
$(1 - P_{R1}(A) - P_{R1}(B))\, P_{R2}(A) +$ **(reason 2)**

$(1 - P_{R1}(A) - P_{R1}(B))\, (1 – P_{R2}(A) – P_{R2}(B))\, P_{R3}(A)$ **(reason 3)**

Estimation Parameters

- 2 aspiration levels for the first two reasons
- 1 scale parameter for the logistics distribution of random noises
- 3 ASCs for three reasons
- ASC for the first reason is normal distributed with an additional parameter of std (panel effect)

Experiment



- Upper route has a deterministic travel time
- Lower route has a stochastic travel time
- Each path segment is clickable
- The label shows total travel time

- 74 subjects from University of Massachusetts Amherst
- Mean age: 24.2 years, 6.9 yrs driving
- 54% male, 46% female
- 1767 route choice observations

Estimation Result

- 6 comparing orders
- 5 out of the 6 PPH models have better fit than Rank-Dependent Expected Utility (RDEU) model (Razo and Gao, 2012)
- The RDEU model has been shown to be superior to EU, and mean-std models
- The best model's comparing order: maximum delay, minimum delay and probability of minimum delay
  - Sensitivity to large delays
  - Scenarios grouped by probability

Cross Validation

- Generate 10 independent data sets from original full data .
- Within each data set, 2/3 subjects' route choices used for estimation and the other 1/3 subjects' route choices used for validation.
- MSD (Mean Squared Distance): Squared Distance (SD) is defined as squared difference between proportion of subjects choosing risky route and the probability predicted by the model in a given scenario. MSD is an average over all scenarios' SD.

		RDEU	PPH_3
Average over 10 data sets estimation	FLL	-561.170	-535.013
	$\bar{\rho}^2$	0.306	0.336
	MSD	0.0240	0.0157
Average over 10 data sets validation	FLL	-281.778	-268.095
	$\bar{\rho}^2$	0.299	0.327
	MSD	0.0299	0.0221
No. of Param.		5	7

Conclusions and Future Directions

- The process model (PPH) fits the data better than the utility maximization model (RDEU) in both estimation and prediction.

- Latent classes for different comparing orders in PPH
- Extension to multi-alternative multi-attribute (including multi-outcome) cases for applications in real traffic networks