The 3rd Conference on Innovations in Travel Modeling, Tempe, AZ, May 10-12, 2010

Heuristic Models of Pedestrian Walking Direction Choice

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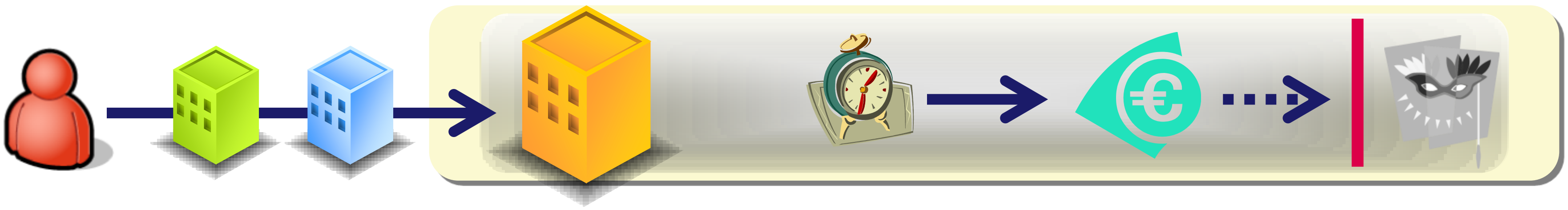
Motivation

- Do people aggregate information when they make choices? (As assumed in utility-based models)

- Or process options and information sequentially due to their bounded rationality? (e.g., Simon, 1956)



- Evidence is mixed. But in travel modeling, using compensatory models is still dominant.

- Purpose: From a practical point of view, to see whether heuristic models can be useful tools for modeling travel behavior.

- Use an example about how shopping pedestrians choose walking directions.

Model comparison

- Heuristic models
  - Conjunctive rule
  - Disjunctive rule
  - Lexicographic rule
- Compensatory models
  - Multinomial logit model
  - Mixed logit model

Data

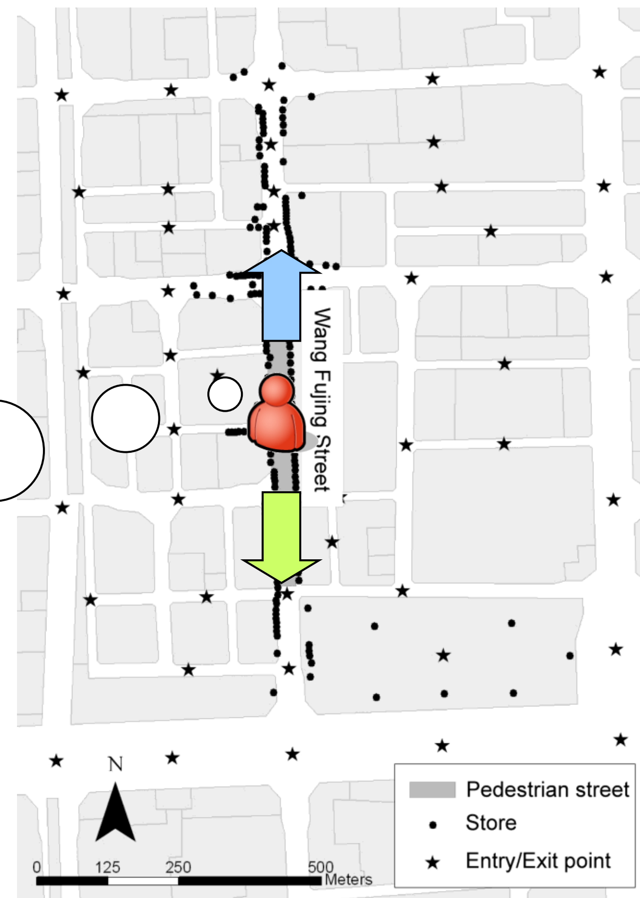
- Data, pedestrians' shopping dairies
- Wang Fujing Street, Beijing, 2004
- 760 respondents

Relevant factors:

- The previsou direction, d^Y (Y=N,S)

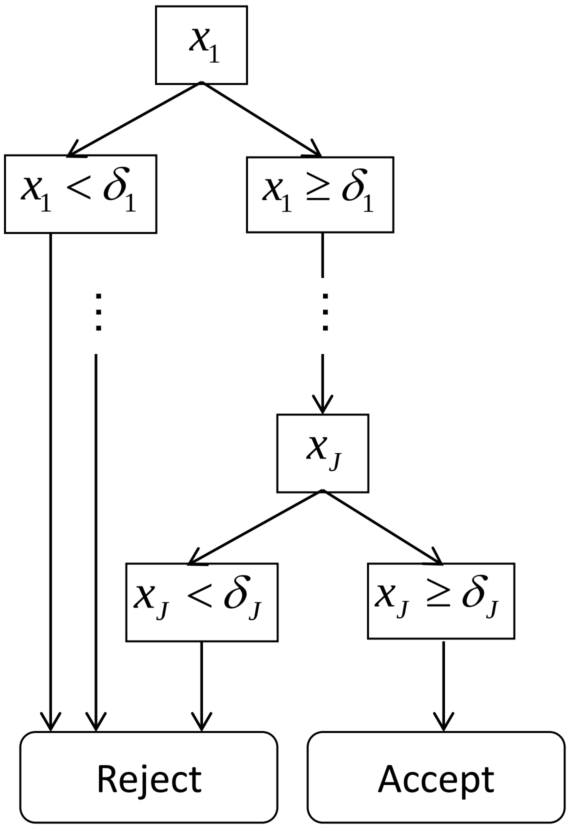
- Total retail floorspace, q^Y

- Length of pedestrianized street, l^Y



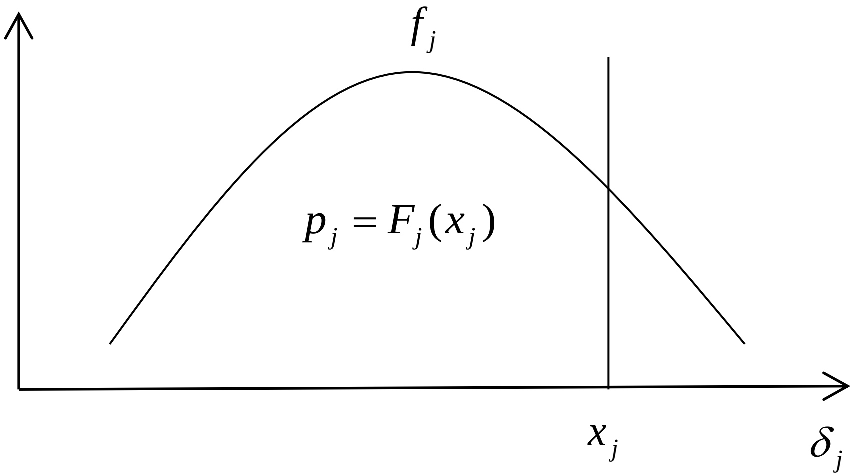
Heuristic models

- Conjunctive: All criteria must be satisfied in order to accept an alternative
- Factor thresholds δ_j



$$p_i = \begin{cases} 1 & \text{if } x_{i1} \geq \delta_1 \wedge \ldots \wedge x_{iJ} \geq \delta_J \\ 0 & \text{otherwise} \end{cases}$$

- Threshold heterogeneity



$$p_1^N = \prod_x p_1^{Nx} \qquad x = d, q, l$$

$$p_1^{Nd} = \alpha^d (1 - d^N) + \beta^d d^N$$

$$p_1^{Nq} = G^q (q^N - \alpha^q, \beta^q, \theta^q)$$

$$p_1^{Nl} = G^l (l^N - \alpha^l, \beta^l, \theta^l)$$

If both directions are satisfactory or unsatisfactory, choose randomly

$$p^N = p_1^N p_0^S + (p_1^N p_1^S + p_0^N p_0^S) 0.5$$

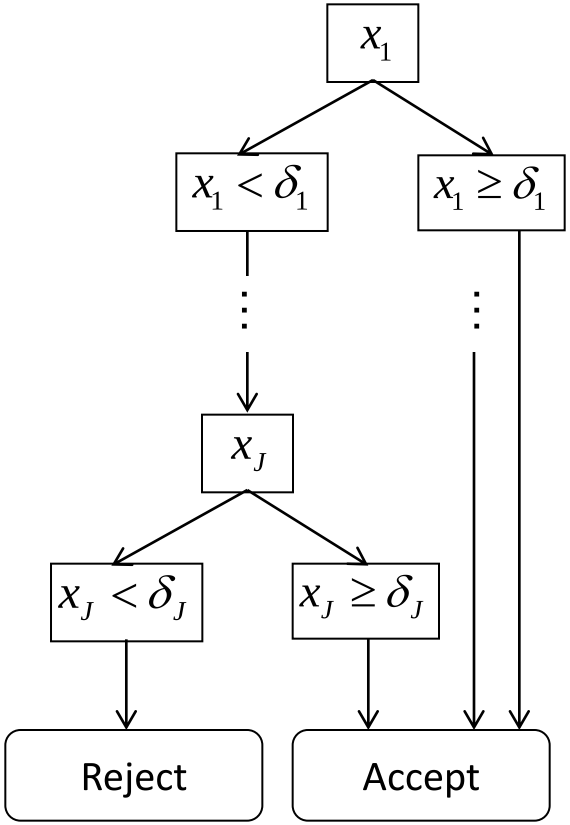
$$p_0^N = 1 - p_1^N$$

- Disjunctive: Only one criterion needs to be satisfied in order to accept an alternative

$$p_i = \begin{cases} 1 & \text{if } x_{i1} \geq \delta_1 \vee \ldots \vee x_{iJ} \geq \delta_J \\ 0 & \text{otherwise} \end{cases}$$

Replace $p_1^N = \prod_x p_1^{Nx}$ with

$$p_1^N = \sum_x p_1^{Nx} - p_1^{Nd} p_1^{Nq} - p_1^{Nd} p_1^{Nl} - p_1^{Nq} p_1^{Nl} + \prod_x p_1^{Nx}$$



- Lexicographic: Compare attributes in descending importance until the attributes discriminate

$$p_1^{Nx_j} = \text{Prob}(x_j \geq \delta_j) \quad \text{Higher state}$$

$$p_0^{Nx_j} = \text{Prob}(x_j < \delta_j) \quad \text{Lower state}$$

$$p_B^{Nx} = p_1^{Nx} p_0^{Sx} \quad \text{Better}$$

$$p_W^{Nx} = p_0^{Nx} p_1^{Sx} \quad \text{Worse}$$

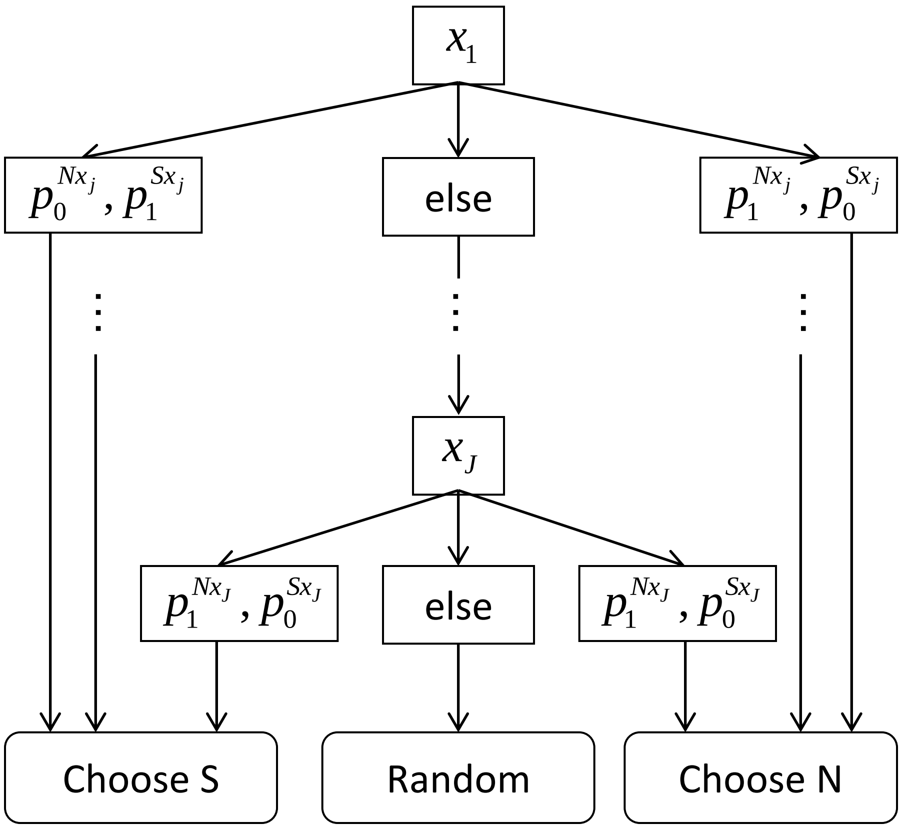
$$p_T^{Nx} = 1 - p_B^{Nx} - p_W^{Nx} \quad \text{Tie}$$

If the sequence is *d* → *q* → *l*

$$p^N = p_B^{Nd} + p_T^{Nd} p'$$

$$p' = p_B^{Nq} + p_T^{Nq} p''$$

$$p'' = p_B^{Nl} + p_T^{Nl} 0.5$$



Compensatory models

- Multinomial logit

$$p^Y = \frac{\exp(v^Y)}{\sum_{Y'} \exp(v^{Y'})} \qquad Y, Y' = N, S$$

$$v^Y = \beta^d d^Y + \beta^q q^Y + \beta^l l^Y$$

- Mixed logit
  - Assumed parameters in MNL are normal distributions

Results

Model	N^P	LL	CAIC
Conjunctive	5	-966	1,975
Disjunctive	3	-987	2,000
Lexicographic $d \to q \to l$	5	-963	1,968
Lexicographic $d \to l \to q$	5	-962	1,968
Lexicographic $q \to d \to l$	4	-946	1,926
Lexicographic $q \to l \to d$	4	-953	1,941
Lexicographic $l \to d \to q$	4	-970	1,974
Lexicographic $l \to q \to d$	4	-953	1,941
MNL standard	2	-989	1,996
MNL with logged variables	3	-991	2,008
Mixed logit	6	-988	2,029

	Lexicographic $q \rightarrow d \rightarrow l$	
	Parameter	Estimate
Prob of turning back	α^d	0.381 *
Prob of following the previous direction	β^d	0.767 *
Threshold for floorspace	α^q	17,999.620 *
	β^q	-
	θ^q	-
Threshold for pedestrian street length	α^l	348.636 *
	β^l	-
	θ^l	-
	N^C	2,098
	N^P	4
	LL	-946
	CAIC	1,926

Conclusion

- Models of non-compensatory decision mechanisms can fit the data well. They can be practically useful for predicting travel behavior.

- Models of sequential processing do not rely on covariance, which may lower the risk of over-fitting. (When one reason suffices, why use another?)

Future directions

- Apply heuristic models on more complicated decision problems to test their general utility.

- Could transportation practices benefit from the sequential mechanisms in heuristic models? Is less-is-more effect possible?

Thank you

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