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A Joint-revealed And Stated Preference Analysis Of Travel Behavioral Responses To Monetary Incentives

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Introduction

Goal: Evaluate the effectiveness of monetary incentives in influencing travelling behavior in the DC-Baltimore metropolitan area.

Key Challenges:

- Revealed preference and stated preference (RP/SP) survey design.
- Variable selection of different scenarios.

Contribution:

- Figured out behavior responses in different dimensions of travelers with different socio-economic information.

Survey Design

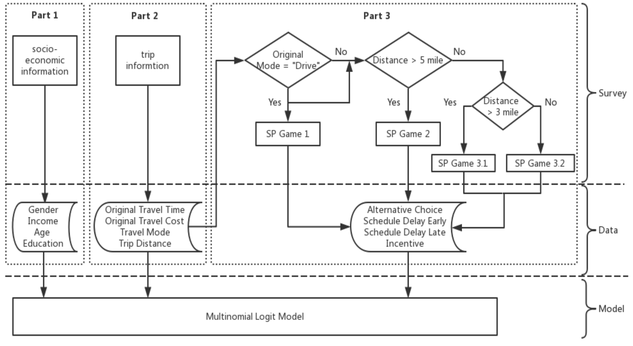

Figure 1. Flow chart of survey design

- All participants will answer the questions in Part 1 (socio-economic information) and Part 2 (trip information).
- Those whose original travel mode is "Drive" take SP Game 1. The long-distance travelers will take SP Game 2, regardless of their original travel modes. The short-distance travelers are guided to SP Game 3.1 and 3.2.

SP Game-1: route/departure time choices

- Alternative departure times and routes are offered, along with the original travel choice made by the survey subject.

SP Game-2: mode choices (long distance)

- Alternative travel modes are offered, including ride-sharing, park-and-ride public transit, walk/bike-access public transit, as well as the original travel choice.

SP Game-3.1 and SP-3.2: mode choices (short distance)

- For subjects who travel a relatively shorter distance (less than five miles), slow travel modes (walk and bike) are offered, along with the original travel choice.

Methodology

Bias and Resampling

- Chi-square tests and sample rebalancing methods are used to detect and correct potential sampling bias for the survey sample dataset.

Multinomial Logit Model

- The utility functions (U_{ij}) are specified for individual i, alternative j: $U_{ij} = \alpha_j + \beta X_{ij} + \gamma_j Y_i + \varepsilon$.
- Where $\alpha_i, \beta, \gamma_j$ denotes the parameters to be estimated; the alternative specific variables X_{ij} include: TT_{ij}, TC_{ij}, SDE_{ij}, SDL_{ij} and $Incentive_{ij}$. Generic variables Y_i include: $gender_i$, age_i, edu_i, inc_i and $trip\_purpose_i$.

Variable Name	Meaning
TT	Total travel time in minutes
TC	Total travel cost in US$
incentive	Monetary incentive in US$
gender	Gender of this respondent, 0: female; 1: male
inc	Income level of this household ($/household/year), 1: <=50k; 2: 50k-100k; 3: >100k
edu	Education level, 1: less than high school; 2: high school; 3: some college; 4: associate; 5: bachelor; 6: graduate or professional
age	Age level, 1: <21; 2: 22-29; 3: 30-39; 4: 40-49; 5: 50-59; 6: >60
trip_purpose	Trip purpose, 0: non-commute; 1: commute

Table 1. Variable Description of the Model

Results

	Route/Departure Time Behavior Response			Mode Choice Behavior Response		
	Variables	Estimate	Sig.[a]	Variables	Estimate	Sig. [a]
Intercept	Original travel plan: intercept	fixed		Original travel plan: intercept	fixed	
	Change route (CR): intercept	-0.462	***	Ridesharing (RS): intercept	0.206	*
	Departure time (DT) 1: intercept	-0.471	***	P&R+transit (P&R+T): intercept	-0.44	***
	Departure time (DT) 2: intercept	-0.384	***	Walk/bike+transit (W/B+T): intercept	-0.567	***
Alternative Specific Variables	TT (min.)	-0.086	***	TT (min.)	-0.015	***
	TC ($)	-0.131	***	TC ($)	-0.05	***
	SDE (min.)	-0.008	***			
	SDL (min.)	-0.01	***			
	Incentive ($)	0.7	***	Incentive ($)	0.069	
Generic Variables	CR: gender = male	-0.137	**	RS: gender = male	0.399	***
	DT 1: gender = male	-0.305	***	P&R+T: gender = male	0.176	**
	DT 2: gender = male	-0.356	***	W/B+T: gender = male	0.676	***
	CR: inc	-0.17	***	RS: inc	-0.118	***
	DT 1: inc	-0.108	***	P&R+T: inc	-0.084	**
	DT 2: inc	-0.178	***	W/B+T: inc	0.197	***
	CR: trip_purpose	-0.029		RS: trip_purpose	-0.253	***
	DT 1: trip_purpose	-0.452	***	P&R+T: trip_purpose	-0.405	***
	DT 2: trip_purpose	-0.433	***	W/B+T: trip_purpose	-0.534	***
	CR: age	-0.099	***	RS: age	-0.331	***
	DT 1: age	-0.219	***	P&R+T: age	-0.264	***
	DT 2: age	-0.248	***	W/B+T: age	-0.564	***

[a] Significance Code: 99% ***; 95% *; 90% *

Table 2. Route/Departure Time and Mode Choice Behavior Response

Result (route/departure time choices)

- Negative intercepts: travelers tend to not change original travel decisions (habitual behavior or behavioral inertia).
- Negative coefficients for travel time, costs, and schedule delay variables, and positive for monetary incentives.
- Female travelers are more likely to consider and change travel choices, while commuters and older citizens are more willing to stick to their original travel plan.

Result (mode choices)

- More significant inertia in switching to transit modes: negative intercepts for the transit alternatives, park-and-ride and walk/bike access transit. Travelers are more willing to embrace ridesharing under monetary incentives.
- Positive coefficient of incentive: but relatively smaller compared to the route and departure time model.
- Higher-income groups: more willing to switch travel modes to walk/bike access transit. Other behavioral response patterns are similar as the route and departure time modeling results.

Discussions

Positive Influence with Behavioral Inertia

- The monetary incentives significantly influence the travel behavior decisions. Moreover, it is empirically found that people is reluctant in changing habitual modes and in this case, higher monetary incentives are necessary to stimulate any modal shifts, compared to what is offered in route and departure time change scenarios.

Decision Supporting

- For policymakers, an easier way to encourage drivers to avoid rush hour trips is to offer them alternative routes, followed by different departure time and travel modes.

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