Stated Preference

Theory and Applications

Nebiyou Tilahun

tila0006@umn.edu

University of Minnesota

Department of Civil Engineering

Outline

- Introduction
- Data types
- Choice
- Applications
  - Valuing Bicycle Facility Features
  - A Moment of Time (Reliability and Route Choice)
- Conclusion

Introduction

- Much of what we do as transportation planners, analysts depends on data and making sense of it
- Different sources of data are available
  - Travel behavior data
  - Time use data
  - Traffic count data
  - Land Use data
  - Accident counts
  - Census and many more.
- Data collection methods vary
  - Questionnaire
  - Observation
  - Sensors
  - Experiment etc...

Data Types

- Travel Behavior Inventory
  - Travel Diary of 1% sample of population (all trips made on one day) every 10 years
  - Socioeconomic/demographic data of survey respondents
- Collection methodology:
  - Phone,
  - Mail,
  - In-Person at Home,
  - In-Person at Work,
  - Roadside
- Use
  - to update regional travel forecasting model

Data Types

- Revealed Preference
  - Whom you voted for. (after the election - your preference is revealed by your vote)
  - Which route you took on your trip from home to work.
- Stated Preference
  - If the election were to be held today, who would you vote for?
  - Given candidates X and Y, who have such and such policy positions, who would you vote for? (Note: question not bound by who is in the running. Comparing importance of policy positions.)
  - If route 1 has X_1, Y_1 attribute, and route 2 has X_2, Y_2 as attributes, which route would you take on your trip from home to work?

Data Types

- Revealed Preference
  - What people actually do, not what they say they will do
  - Budget and other restriction are “real””
  - Researcher does not know the choice set decision maker considered
  - Can not test for new policy considerations
  - Can only examine existing market conditions

Data Types

- Stated Preference
  - What people say they will do
  - Budget and other restriction are NOT “real”
  - Researcher controls the attributes presented and the relationships between them
  - Can examine alternatives that are not yet in the market

Data Types

	Revealed Preference	Stated Preference
What people ...	do	say they would do
Constraints are ...	real	specified
Consequences ...	experienced	not experienced
Alternatives ...	constrained	not constrained
Environment...	not controlled	controlled
Source...	many sources	survey
Survey design	important	important

Discrete Choice

- Decision maker - individual, household, firm etc... characteristics
- Alternatives - what has been chosen, what were the alternatives?
- Attributes - refer to characteristics of the alternatives
- Decision rule - most often *utility theory* is used in transportation.

Choice

- Utility (Ordinal)
  - Scalar measure of preference
  - Derived from the characteristics of goods
  - For alternative a and b, choice depends on whether $U_a >, <, or = U_b$
  - Ordering is what is important
- Rational individual
  - Consistent (will repeat the same choice, under similar circumstances)
  - Transitive (if A is preferred to B, B preferred to C, then A is preferred to C)
- Individual chooses the alternative with the highest Utility

Choice

- Probability that alternative i is chosen equals the probability that its utility is larger than all alternatives j in the choice set.

for the binary case

$$\begin{aligned} P_n(i) &= Pr(U_{in} > U_{jn}) \\ &= Pr(V_{in} + \epsilon_{in} > V_{jn} + \epsilon_{jn}) \\ &= Pr(\epsilon_{jn} - \epsilon_{in} < V_{in} - V_{jn}) \\ &= Pr(\epsilon_n < V_{in} - V_{jn}) \end{aligned}$$

If we assume ϵ_n has a logistic distribution

$$P_n(i) = \frac{e^{\mu V_{in}}}{e^{\mu V_{in}} + e^{\mu V_{jn}}}$$

Application

Trails, Lanes, or Traffic: The Value of Different Bicycle Facilities Using Adaptive Stated-Preference Survey

Trails, Lanes or Traffic

- Aim: to quantify preferences between different attributes of cycling facilities.

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- What do people want?
  - How much is a bike lane worth to you?
  - How much is having an off-road facility worth to you?
  - How much is having parking removed from the side street worth to you?

Trails, Lanes or Traffic

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- What do people want?
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- Are there differences across Age, Gender, and Income in preferences?

Trails, Lanes or Traffic

- Stated Preference Survey
  - Hypothetical alternatives are presented with different attributes
  - Respondents asked to make a choice based on the information provided.

Trails, Lanes or Traffic

- Stated Preference Survey
  - Hypothetical alternatives are presented with different attributes
  - Respondents asked to make a choice based on the information provided.
- Why not Revealed Preference?
  - Data difficult to find.
  - Choices are constrained by what facility is physically available.

Trails, Lanes or Traffic

- Adaptive Stated Preference Survey
    - Choices attributes updated based on previous response.
    - Ensure meaningful tradeoffs
- Bicycling in facility A vs. in B
    - Compare two bicycle facilities and tradeoff travel time and facility quality.

Trails, Lanes or Traffic

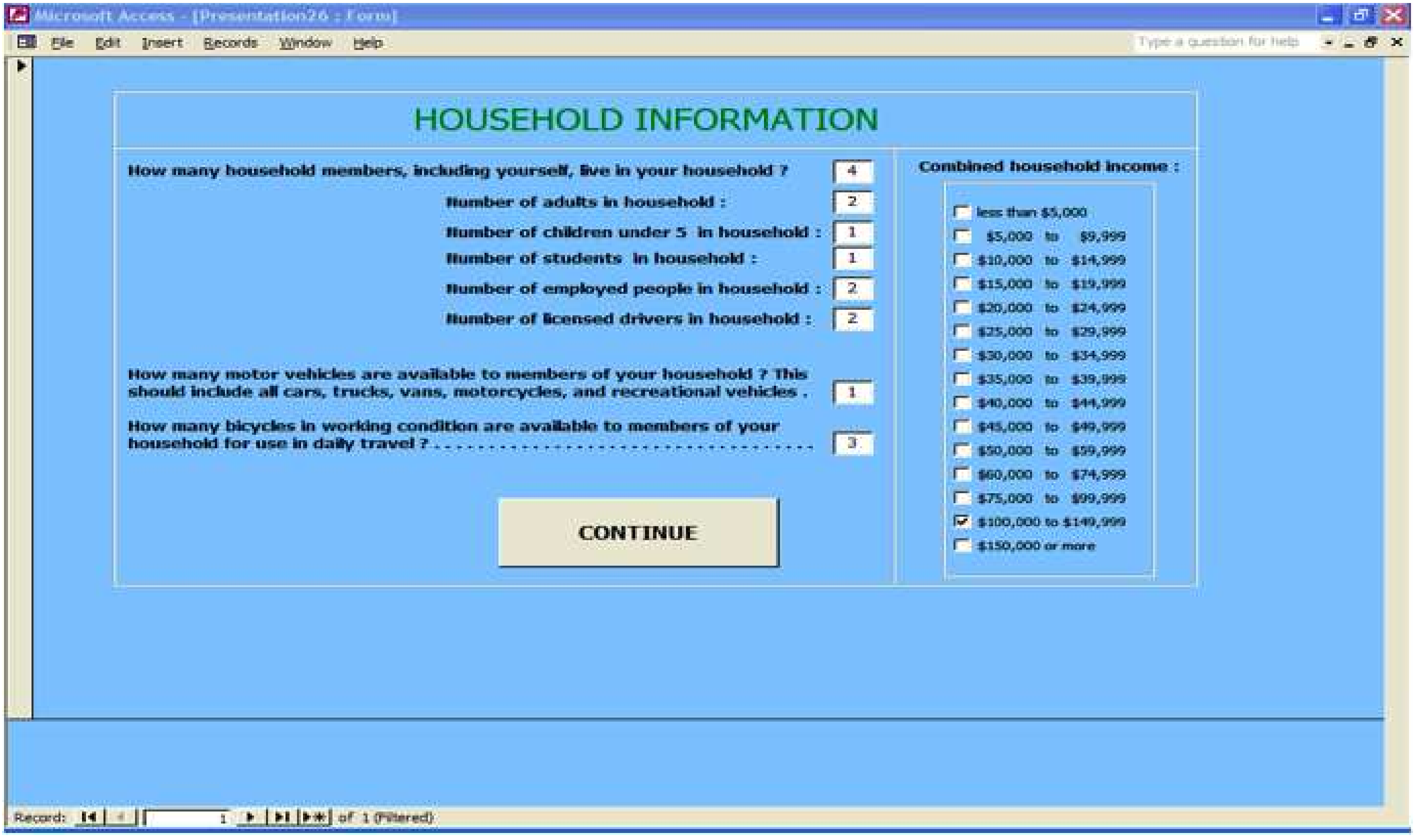
- Facilities considered in this study
  - A - Off Road
  - B - Designated Bike Lane with No Side Parking
  - C - Designated Bike Lane with Side Parking
  - D - In-traffic Bicycling with no Side Parking
  - E - In-traffic Bicycling with Side Parking

Trails, Lanes or Traffic

Sample Question

Trails, Lanes or Traffic

Household Information



Trails, Lanes or Traffic

- Switching Point Analysis
  - What is the maximum travel time difference, at which the person chooses the “better” facility?
  - Adaptive Stated Preference allows us to identify the switching point

Presentation	Route 1 (min)	Route 2 (min)	Choice
Choice set 1	40	20	Route 2
Choice set 2	30	20	Route 1
Choice set 3	35	20	Route 1
Choice set 4	37	20	Route 2

Switching point = 36 Minutes

Trails, Lanes or Traffic

Hierarchy of facilities

Facility 1	Facility 2	Travel time
A	B	14.21
A	C	16.00
A	D	18.46
A	E	23.14
B	C	10.13
B	D	13.73
B	E	20.87
C	E	19.65
D	E	18.25

Trails, Lanes or Traffic

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$$A > B > C > D > E$$

Trails, Lanes or Traffic

- Represent facility by its component attributes

Facility	Off road	Bike lane	No Parking
A	1	1	1
B	0	1	1
C	0	1	0
D	0	0	1
E	0	0	0

- Other ways of breaking down the facility features are also possible.

Trails, Lanes or Traffic

Model fitting

- Linear Regression Model

$$T_{ij} = \beta_0 + \beta_1 O_{ij} + \beta_2 B_{ij} + \beta_3 P_{ij} + \ldots$$

- Binomial Logit Model

$$log[\frac{p_{ij}}{1 - p_{ij}}] = \beta_0 + \beta_1 O_{ij} + \beta_2 B_{ij} + \beta_3 P_{ij} + \beta_4 T_{ij} + \ldots$$

  - p_{ij} - Probability person i chooses alternative j.
  - O - Off road
  - B - Is there a designated bike lane? (1=Yes, 0= No)
  - P - Is there parking (1=Absent, 0=Present)
  - T - Travel time on facility
  - ... - Season and Individual variables

Trails, Lanes or Traffic

Time-values of attributes from logit model

Attribute	Calculated	Estimate (minutes)
Off-street	β_1/β_4	5.13
Designated Bike lane	β_2/β_4	16.41
No Parking	β_3/β_4	9.27

Trails, Lanes or Traffic

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Summary

- Data shows a hierarchy of facilities

  $A > B > C > D > E$

Trails, Lanes or Traffic

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Summary

- Data shows a hierarchy of facilities

  $A > B > C > D > E$

- Model shows a hierarchy of attributes

  $B > P > O$

Application

A Moment of Time: Reliability in Route Choice using Stated Preference

A Moment of Time

- **We seek to value travel time reliability.**

A Moment of Time

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Travel Time Reliability

- The probability that a given trip can be made in a specified amount of time.
- Impacted by:
  - Incidents
  - Work zones
  - Weather
  - Demand fluctuations
  - Inadequate capacity
  - Special events ...

A Moment of Time

- The route choice decision is a recurring problem for the traveler.
- We hypothesize that decisions depend on
  - direct monetary cost
  - the mode of travel time (most frequent experience)
  - possibility of early or arrival
- In other words, individuals use the mode to position their preference on a particular route and then consider how much early or how much late they can be from that position.

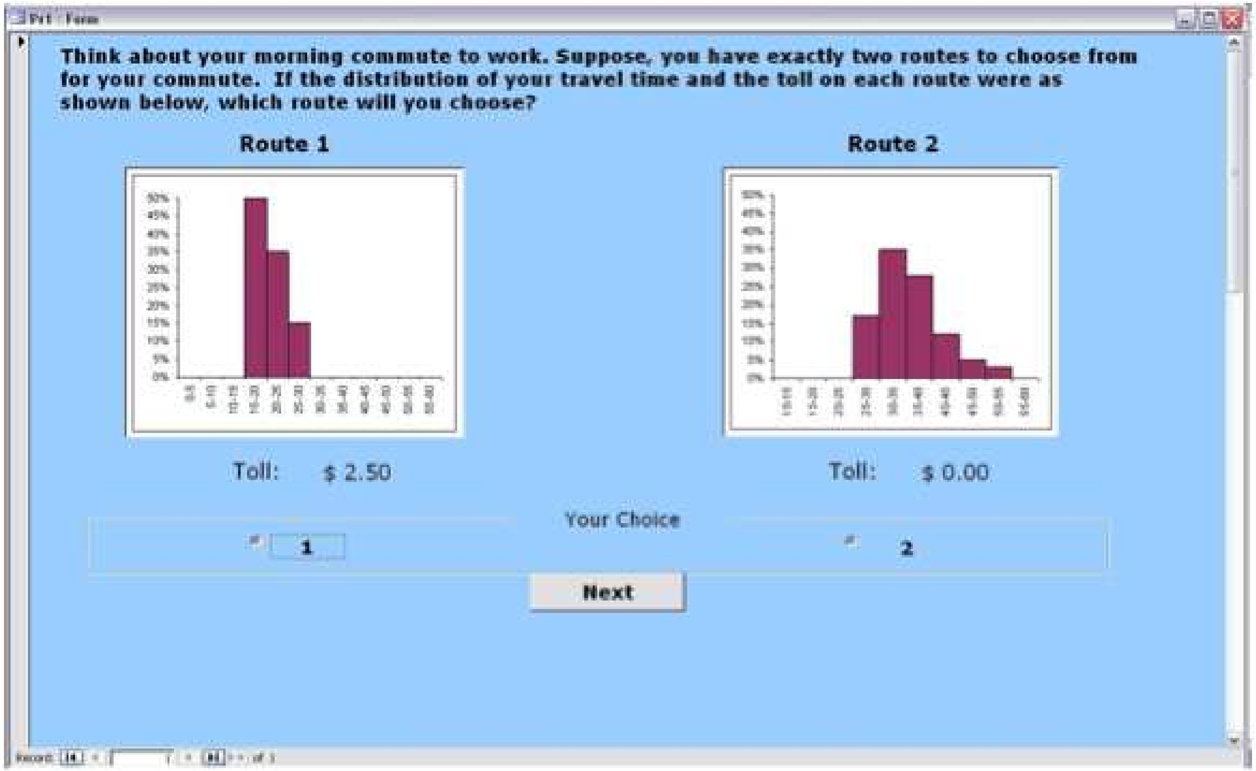
A Moment of Time

Why use Stated Preference:

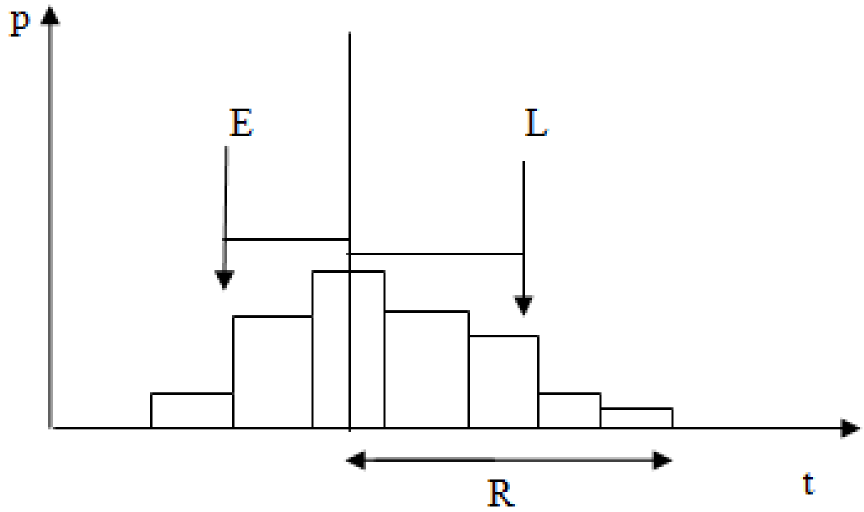
- Revealed data may not be available.
- Revealed data are likely to be correlated.
  - more reliable service, is priced more.
  - less reliable service, is priced less.
  - routes that save time, are priced more.
  - routes that cause delays are under-priced.
- Revealed data may not exhibit sufficient variability for estimation.
  - Small range of travel time.
  - Small range of cost.
- Easier to get data.

A Moment of Time

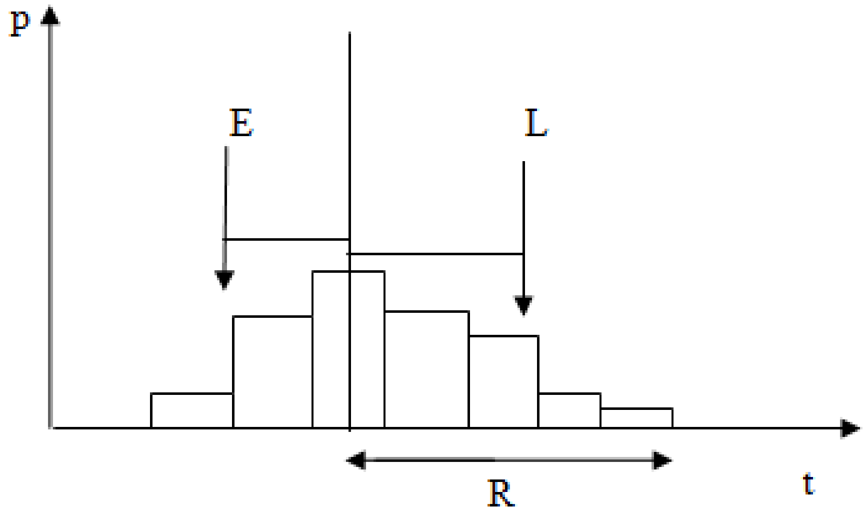
Sample Question



A Moment of Time



A Moment of Time

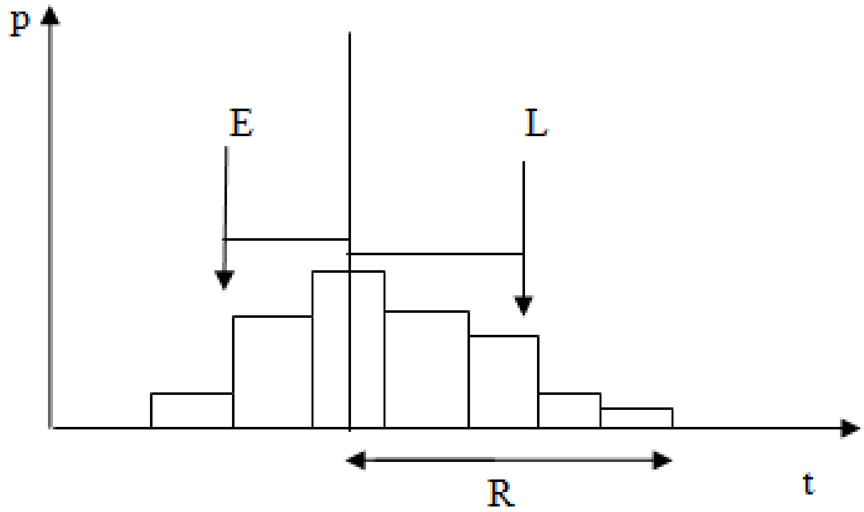


$$E = \frac{1}{P(t < T)} \sum p_i \delta_i (T - t_i) \quad where \quad \delta_i = \begin{cases} 1 & \text{if } T \geq t_i \\ 0 & \text{if } T < t_i \end{cases}$$

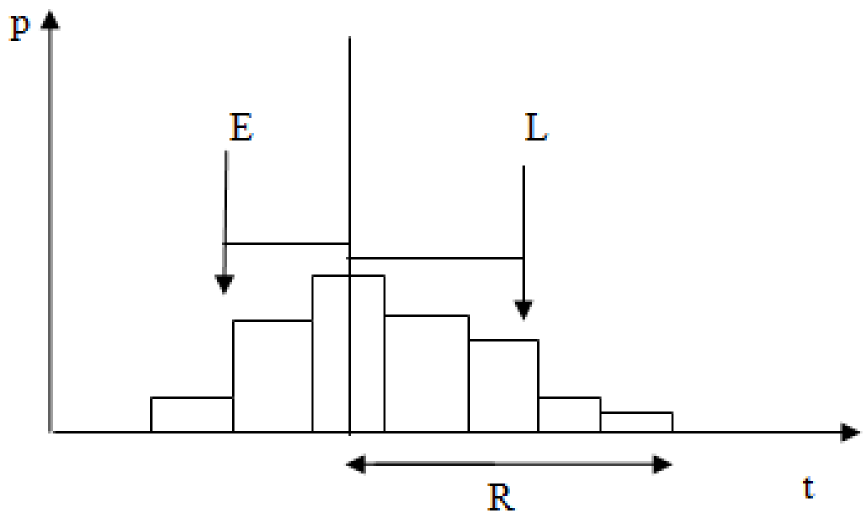
$$L = \frac{1}{P(t > T)} \sum p_i \delta_i (t_i - T) \quad where \quad \delta_i = \begin{cases} 1 & \text{if } T \leq t_i \\ 0 & \text{if } T > t_i \end{cases}$$

mode travel time, and toll also used to characterize each route.

A Moment of Time



A Moment of Time



Alternately, we can use

- the mean travel time, standard deviation, and toll
- the mode travel time, standard deviation, and toll
- the mode travel time, range (R), probability of lateness and toll

to characterize each route.

A Moment of Time

$$(Y_{ij}/b_i) \sim binomial(1, p_{ij})$$

$$logit(p_{ij}) = U_{ij} + b_i$$

$$b_i \sim N(0, \sigma^2)$$

$$U_{ij} = V_{ij} + \epsilon_{ij}$$

$$\begin{aligned}
V_{ij} &= \beta_0 + \beta_1 T_{ij} + \beta_2 C_{ij} + \beta_3 E_{ij} + \beta_4 L_{ij} \\
V_{ij} &= \beta_0 + \beta_1 T_{ij} + \beta_2 C_{ij} + \beta_3 R_{ij} + \beta_4 P_{ij} \\
V_{ij} &= \beta_0 + \beta_1 T_{ij} + \beta_2 C_{ij} + \beta_3 S_{ij}
\end{aligned}$$

A Moment of Time

$$
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\end{aligned}
$$

- T : Mode travel time
- C : Toll cost of the trip
- E : Expected earliness when early.
- L : Expected lateness when late.
- R : Right range of the travel time distribution
- P : Probability of being over 5 minutes late from usual
- S : Standard deviation of travel time experienced

A Moment of Time

	Model 1			Model 2			Model 3		
	Estimate	Std.Error	p-val	Estimate	Std.Error	p-val	Estimate	Std.Error	p-val
σ^2 (Subject)	2.954	0.474	0.000	3.037	0.486	0.000	2.879	0.463	0.000
Constant	1.902	0.427	0.000	1.413	0.494	0.005	1.835	0.427	0.000
T (Time)	-0.273	0.020	0.000	-0.287	0.020	0.000	-0.295	0.022	0.000
C(Cost)	-2.201	0.145	0.000	-2.137	0.139	0.000	-2.262	0.156	0.000
E (Early)	0.015	0.029	0.615						
L (Late)	-0.261	0.052	0.000						
R (Right Range)				-0.082	0.026	0.002			
P (Prob >5 min late)				-2.999	1.092	0.007			
S (Standard Deviation)							-0.261	0.085	0.002
A (1= > 35, 0 otherwise)	-0.643	0.340	0.060	-0.651	0.344	0.060	-0.636	0.336	0.060
G(Male=1, Female=0)	-0.557	0.294	0.060	-0.565	0.297	0.059	-0.551	0.290	0.060
I (1 if > 60K)	-1.248	0.488	0.011	-1.261	0.494	0.011	-1.231	0.483	0.012
M (1=Car, 0 otherwise)	-1.160	0.329	0.001	-1.175	0.333	0.001	-1.146	0.325	0.000
Value of Time	$ 7.44	0.358	0.000	$ 8.07	0.328	0.000	$7.82	0.293	0.000
$VOR1^a$ ($/hr)	$ 7.11	1.357	0.000						
$VOR2^b$ ($/hr)				$ 2.31	0.757	0.003			
$VOR3^c$ ($/% increase)				$ 0.84	0.303	0.006			
$VOR4^d$ ($/hr)							$ 6.93	2.066	0.001
Reliability Ratio							0.89	0.265	0.001
Fit Statistics									
Subjects	177			177			177		
Question per Subject	13			13			13		
-2logLiklihood	2004.8			1986.1			2023.3		

[a] value of reliability (per hour decrease in the average lateness)
[b] value of reliability (per hour decrease in right range)
[c] value of reliability (per percentage point change in lateness probability)
[d] value of reliability (per hour decrease in the standard deviation)

A Moment of Time

- Each of the measures of reliability tells us something slightly different.
- But they are not entirely independent of one another.
  - In slightly different ways each is measuring the spread of the travel time.
  - not entirely surprising that all three measures of reliability came out significant.
  - It is important to look at what each formulation implies.

A Moment of Time

Model 1:

- probabilities work as weighing factors to moderate the effects of extreme travel times.
- larger probabilities give importance to outcomes that are more commonly observed.

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Model 2

- looks at the range and the distribution separately.
- does not distinguish between distributions that have similar lateness probabilities and range.

A Moment of Time

Model 1:

- probabilities work as weighing factors to moderate the effects of extreme travel times.
- larger probabilities give importance to outcomes that are more commonly observed.

Model 2

- looks at the range and the distribution separately.
- does not distinguish between distributions that have similar lateness probabilities and range.

Model 3

- measures the overall variation using the standard deviation
- however it gives importance to early arrival that the more detailed models 1 and 2 do not show.

A Moment of Time

- Overall, these results support the idea that reliability offers policy opportunities that may be used to improve the transportation experience of users.
- This is especially the case as demand is continuously increasing, without concomitant increases in capacity.
- By recognizing the various susceptibilities of different types of networks, transportation policy makers can derive significant benefits to users.

Questions