Think about your morning commute to work. Suppose, you have exactly two routes to choose from for your commute. If the distribution of your travel time and the toll on each route were as shown below, which route will you choose?

**Route 1**

- **Toll:** $2.50

**Route 2**

- **Toll:** $0.00

Your Choice

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11th International Conference on Travel Behavior Research
The Expanding Sphere of Travel Behavior Research
Kyoto, August 16-20, 2006, Japan
A Moment of Time

• The route choice decision is a recurring problem for the traveler.
• In this research, we hypothesize that in addition to direct monetary cost
  – the statistical mode of travel time or the most frequent experience is what drives the decision to use a particular route
  – the person making the decision would also take into consideration late or early arrival as a possible outcome.
• In other words, individuals use the mode of time to position their preference on a particular route and then consider how much early or how much late they can be from that position.
Methodology

- A Computer Administered Stated Preference survey is used to test our hypothesis.
- Pros
  - Allows us to test a variety of travel time and cost combinations that in reality are difficult to acquire for each individual.
  - Gives us more control over the variables of interest and overcomes many of the consistency problems that arise in revealed preference data.
- Cons
  - Possibility of unreasonable choices because of misunderstanding the problem
  - No real consequences of the choice.
- To eliminate the first of these, this study included control questions randomly placed among the route alternatives. These questions presented a clearly dominated choice alternatives for the respondents.
Prior to starting the survey, subjects were given a short **tutorial** to help them understand distributions as they relate to hypothetical travel time distributions.

The tutorial covers interpreting frequencies, mean and variance identification and what these imply in comparing alternatives.

Each respondent got the question in one of three randomized orders, in half of which alternatives were placed top and bottom and in half side by side.
Example (Question)

Think about your morning commute to work. Suppose, you have exactly two routes to choose from for your commute. If the distribution of your travel time and the toll on each route were as shown below, which route will you choose?

Route 1

Toll: $2.50

Route 2

Toll: $0.00

Your Choice

# 1

# 2

Next
Subjects

• Subjects for the survey were recruited via email from the University of Minnesota’s employee database. A target of 200 was set.

• Invitations were sent out to 2500 randomly selected non-faculty, non-student employees who had not participated in previous transportation studies conducted by the authors. 187 participated.

• $15 for participation. Participants came to a central testing station, where the survey was being administered.

• Of these ten were dropped from the analysis
  – Eight of those because they made irrational choices on control questions indicating possible misunderstanding.
  – Two more because they failed to provide demographic information that were used in the model fitting.
The mode ($T$), the average late ($L$) or average early ($E$) from the most frequent experience is a representative way of getting together the possible range and frequencies experienced.

- $E = \text{Average Early from Mode}$
  \[
  E = \sum \frac{p_i(T-t_i)}{P(t < T)}
  \]

- $L = \text{Average Late from Mode}$
  \[
  L = \sum \frac{p_i(t_i-T)}{P(t > T)}
  \]

- $T = \text{Mode of Distribution of Time}$
  \[
  t_i < T \quad \text{for E}
  \]
  \[
  t_i > T \quad \text{for L}
  \]
SPECIFICATION

\[ \ln\left(\frac{P}{1-P}\right) = f(T, C, L, E, A, S, D, I, O, M) \]

Binomial Logit Model

- \( P \) = Probability of choosing a route (alternative 1 (most reliable alternative)).
- \( T \) = Most frequent travel time
- \( C \) = Toll cost of the trip
- \( L \) = On Average how late a traveler can be from \( T \)
- \( E \) = On Average how early a traveler can be from \( T \)
- \( A \) = Age
- \( S \) = Sex (0 = Female, 1 = Male)
- \( D \) = Education (0 = Below College, 1 = College Educated)
- \( I \) = Personal income
- \( O \) = Reported commute time
- \( M \) = Usual mode of travel (1 = Car, 0 = Other)
# Model: A Moment of Time

| Variable                      | Estimate | Odds | Std. Error | z value | Pr(>|z|) |
|-------------------------------|----------|------|------------|---------|---------|
| (Intercept)                   | 2.066    | 7.897| 0.3035     | 6.81    | 0.000   | *** |
| Time (Mode)                   | $T$      | -0.189| 0.828      | 0.0151  | -12.52  | 0.000 | *** |
| Toll                          | $C$      | -1.528| 0.217      | 0.1096  | -13.95  | 0.000 | *** |
| Average Early                 | $E$      | 0.010 | 1.010      | 0.0241  | 0.41    | 0.686 |
| Average Late                  | $L$      | -0.176| 0.839      | 0.0424  | -4.15   | 0.000 | *** |
| Age                           | $A$      | -0.015| 0.985      | 0.0048  | -3.16   | 0.002 | **  |
| Sex(1=Male, 0=Female)         | $S$      | -0.496| 0.609      | 0.1051  | -4.72   | 0.000 | *** |
| Education (1=College, 0=Below College) | $D$   | -0.486| 0.615      | 0.1291  | -3.77   | 0.000 | *** |
| Income                        | $I$      | -0.007| 0.993      | 0.0035  | -2.14   | 0.033 | *   |
| Reported Commute Time         | $O$      | 0.010 | 1.010      | 0.0037  | 2.54    | 0.011 | *   |
| Mode (1=Car, 0=Other)         | $M$      | -0.882| 0.414      | 0.1113  | -7.93   | 0.000 | *** |

| Null deviance:                | 2784.8   | on 2300 degrees of freedom |
| Residual deviance:            | 2384.3   | on 2290 degrees of freedom |
| AIC (Akaike Information Criterion) | 2406.3 | |
| Pseudo $R^2$                  | 0.14     | |
| Subjects                      | 177      | |
| VOT based on $T$              | $7.43    | /hr |
| VOT based on $L$              | $6.91    | /hr |

Model: A Moment of Time
Results

• The results of the model support the hypotheses that all but variable $E$ are important determinants of choice.
• Individuals are making a choice based on whether the mode of travel time is small, whether the average lateness expected from a particular route is small, and how much toll is paid on a particular route.
• There is no evidence to suggest that the possibility of early arrival has any bearing on the decision to pick a particular route.
• Of these three determinants, the strongest disincentive from choosing a particular route is the **toll**, followed by the **mode of travel time** and finally the magnitude of **average late arrival** on that route.
**Results**

- A one minute increase in the mode ($T$) results in a 17% reduction in the odds of choosing a particular route,
- A one minute increase in the average late time ($L$) reduces the odds of choice by about 16%.
- A one dollar increase on the toll reduces the odds by close to 78%.
- There is a considerable overlap between $T$ (CI (-0.219,-0.160)) and $L$ (CI (-0.259,-0.09)) which indicates that the mode travel time and the possibility of lateness are valued very close to one another.
Results

- The value of time based on the mode $T$ is $7.43$ per hour, while the lateness penalty $L$ $6.91$ per hour. (This value is lower than much research, and is derived from tolls, to which there may be an inherent aversion.)

- The Marginal Rate of Substitution of between $L$ and $T$ is $0.93$ which indicates that other things the same, for every one minute increase in $L$, one could reduce $T$ by $0.93$ minutes and remain at the same utility.

- This finding suggests that an approximately equal magnitude of utility can be derived on average by increasing reliability as can be from reducing the usual travel time users experience.
**Results**

Those more tolerant of unreliability were:
- Older individuals - For each additional increase in age there is a 1.5% decline in odds of choosing the more reliable alternative.
- Men - We find that there is on average a 39% decrease in the odds of choosing the more reliable alternative when the choice maker is male.
- The educated and the wealthy.
- Those with shorter commutes.
- Car users.

Those less tolerant of unreliability (more demanding of reliability) were:
- Younger individuals
- Women
- The less educated and the less wealthy
- Those with longer commutes
- Transit and bike users
Summary

• The paradigm adopted in this study considers the mode travel time as the important indicator of a road’s performance to the user rather than the average.
• In addition it is hypothesized that users trade off the extent to which one route may serve better than another, by using the average time late and average time early from the mode.
• The results do not provide evidence that early arrival is important in decision making.
• Both the mode and average time late are important contributors to route choice.
• The results further indicate that the mode and lateness are valued very close to one another.
Questions
Reliability: Measures of Stability of Service

• Connectivity Reliability
  – Probability that network nodes remain connected.

• Capacity Reliability
  – Probability that a network can handle a specified amount of demand at a desired level of service.

• Travel Time Reliability
  – The probability that a given trip can be made in an expected amount of time.
– Gaver (1968) shows that travelers leave earlier than they otherwise would, had there been no variability in travel time.
– Jackson and Jucker (1981) tried to explicitly address tradeoff between travel time and its variability.
– Small (1982) empirically estimates a model for scheduling work trips that explicitly considers early and late arrival probabilities.
Notice the following graphical representations:

The figure on top represents another possible distribution.

The figure on the bottom is the same one shown on the previous slide.

We can see that the graphical representation on top:

- has a wider range of trip times (10-55 minutes).
- has lower frequency of trips that take between 20-25 minutes.
- has a bigger variability of the travel times about the center.
- The percentages in both cases add up to 100%.
- For both distributions the average is about 25 minutes.