$EC_4$ ($6,200-7,500$

$EC_5$ ($7,500$

and over)

$CR_1$ (0-0.5)

$CR_2$ (0.5-1.0)

$CR_3$ (1.0-1.5)

$CR_4$ (1.5 and over)

$TTR$: Ratio of transit to auto time

$CR$: Ratio of transit to auto cost

$L$: Ratio of transit to auto service

$EC$: Annual median income per worker

Range for ($L$) service time ratios:

$L_1$: 0.0 to 1.5

$L_2$: 1.5 to 3.5

$L_3$: 3.5 to 5.5

$L_4$: 5.5 and over

Curves based on actual data from:

- Washington, D.C.
- Philadelphia
- Toronto

Curves hypothesized for Washington, D.C.:

--- Washington

Fig. 7.17 Work-trip modal-split relationships for Washington, D.C., Philadelphia, and Toronto.
The utility expression for auto passenger could be set to zero, making the exponential expression \( e^{U_{AP}} \) equal to one, since the other two modes were compared to that for the auto passenger.

The linear utility expressions for the two modes, auto drivers and transit, for CBD trips were

\[
U_{AD} = -1.4809 + 1.9500 (T135) 
\]

\[
U_{TP} = 1.1636 + 0.0916 (DX3) + 0.0563 (DL3) + 0.0106 (DCH) 
\]

and for non-CBD trips,

\[
U_{AD} = -0.5441 + 2.6800 (T135) 
\]

\[
U_{TP} = 1.6600 + 0.1314 (DX3) + 0.0192 (DL3) + 0.0184 (DCH) 
\]

where T135 = transformed household income variable

\( = 1 - e^{-0.035l} \), where \( l \) is annual household income (in $1,000)

DX3 = difference in excess time

\equal\ (auto terminal time at origin) + (auto terminal time at destination) - (walk to transit time) - (transit wait time) - (walk from transit time)

DL3 = difference in line haul time

\equal\ (auto travel time) + (auto access time) - (vehicle in transit time) - (transfer time)

DCH = difference in travel cost

\equal\ (5 cents/mile \times auto distance) + (auto parking cost/2) - (transit fare)

Differences in line-haul time, excess time, and travel cost turned out to be the most appropriate transportation system variables, while income was the only socioeconomic variable that was statistically significant. The transportation system variables were created on the basis of the following assumptions:

1. Auto and transit vehicle times and distances were calculated along zone-to-zone peak-hour minimum time paths on the highway and transit networks, respectively.
2. Auto access times—those taken by the traveler while using local streets to access the principal highways—ranged from 0 min in the CBD, to 1 to 2 in the densely settled areas, to 5 and above in the outlying zones.
3. Auto terminal times—taken for (1) walking between the parking lot and the actual origin or destination of the trip, and (2) waiting or walking within the parking facility—were calculated as a function of the availability of parking spaces in a zone.
4. Auto parking costs were computed as the average daily values for each zone.
5. Walk-to-transit times were based on the average walking times to transit networks for each zone.
6. Transit waiting times were equated to half the transit headway times, up to a maximum of 15 min.
7. Transit transfer times were taken as half the transit headways at the transfer points.
8. Transit fares were developed from a fare matrix based on the most probable zone-to-zone transit routes.
There are 33% and 66.8% chance that the individual will use auto to work and

\[
\frac{\alpha + \beta}{\alpha} - \frac{\alpha + \beta}{\beta} = \frac{dI}{dF} \quad (\psi)
\]

\[
\frac{\alpha + \beta}{\beta} - \frac{\alpha + \beta}{\alpha} = \frac{dV}{dI} \quad (\gamma)
\]

\[
\frac{\alpha + \beta}{\beta} - \frac{\alpha + \beta}{\alpha} = \frac{dI}{dL} \quad (\gamma)
\]

\[
\frac{\alpha + \beta}{\alpha} - \frac{\alpha + \beta}{\beta} = \frac{dV}{dL} \quad (\gamma)
\]

Determining the probability of making a CEP trip by auto and transit

\[
DTC = \text{difference in travel cost}
\]

\[
DII = \text{difference in vehicle time}
\]

\[
DIT = \text{difference in travel time}
\]

\[
\text{INC} = \text{equation for this exercise.}
\]

Linear utility expression for transit passengers: use the following

\[
\alpha + \beta = \frac{dI}{dF} \quad (\psi)
\]

\[
\alpha + \beta = \frac{dV}{dI} \quad (\gamma)
\]

\[
\alpha + \beta = \frac{dI}{dL} \quad (\gamma)
\]

\[
\alpha + \beta = \frac{dV}{dL} \quad (\gamma)
\]

where

\[
\frac{\alpha + \beta}{\beta} + \frac{\alpha + \beta}{\alpha} = \frac{dI}{dF} \quad (\psi)
\]

\[
\frac{\alpha + \beta}{\beta} + \frac{\alpha + \beta}{\alpha} = \frac{dV}{dI} \quad (\gamma)
\]

\[
\frac{\alpha + \beta}{\beta} + \frac{\alpha + \beta}{\alpha} = \frac{dI}{dL} \quad (\gamma)
\]

\[
\frac{\alpha + \beta}{\beta} + \frac{\alpha + \beta}{\alpha} = \frac{dV}{dL} \quad (\gamma)
\]

3. Estimating a Multinomial Logit Model: An Example