CE 486
Urban Transportation Planning

Lec. 4
Modal Split

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Mode Choice

- In most situations, a traveler has a choice of modes
  - Transit, walk, bike, carpool, motorcycle, drive alone
- Mode choice/mode split determines # of trips between zones made by auto or other mode, usually transit

Modal Split Analysis

- This phase of travel-demand forecasting, we analyze people's decision regarding mode of travel; auto, bus, jeepneys, train, and so on, are analyzed

- Mode usage analysis can be done at various points in the forecasting process

- The most common point is after trip distribution because the information on where trips are going allows the mode usage relationship to compare the alternative transportation services competing for users


Jennifer McPhail attempting to get to a bus stop.

- Private
- Taxi
- HOV
- Light Rail
- Heavy rail
- Local bus service
- Express bus service
- Para transit service

Utility and Disutility Functions

- Utility function: measures satisfaction derived from choices
- Disutility function: represents generalized costs of each choice
- Usually expressed as the linear weighted sum of the independent variables of their transformation

$$U = a_0 + a_1X_1 + a_2X_2 + \ldots\ldots + a_rX_r$$

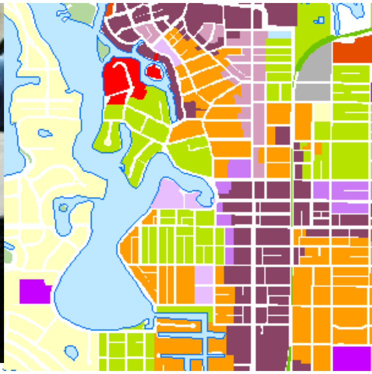
U: utility derived from choice

X_r: attributes

a_r: model parameters

Factors Affecting Mode Split

- Person/household characteristics
  - Auto availability, income, HH size, life cycle
- Trip characteristics
  - Purpose, chaining, time of departure, OD, length
- Land use characteristics
  - Sidewalk/ped facilities, mix of uses at both ends, distance to transit, parking and costs at both ends, density at both ends
- Service characteristics
  - Facility design (HOV, bikes), frequency, congestion, cost (parking, tolls, fares, out-of-pocket costs), stop spacing

Three broad categories of factors that affect the choices that people make are

1. The characteristics of the trip makers (e.g. family income, number of autos available, family size, residential density)
2. The characteristics of the trip (e.g. trip distance, time of day)
3. The characteristics of the transportation system (e.g. riding time, excess time)

Logit Model

- The logit formulation is a share model that divides the persons between the various modes depending on each mode’s relative desirability for any given trip.
- Modes are said to be relatively more desirable if they are faster, cheaper, or have other mode favorable features than competitive modes
- The better a mode is, the more utility it has for the potential traveler.

Logit Models

- Calculates the probability of selecting a particular mode

$$p(K) = \frac{e^{Uk}}{\sum e^{Uk}}$$

Mode Choice

(Logit)

$$Pij = \frac{e^{\text{transit utility}_{ij}}}{e^{\text{transit utility}_{ij}} + e^{\text{auto utility}_{ij}}}$$

Pij = Probability of using transit for a trip between Zone i to Zone j

Transit untility$_{ij}$ = f (transit level of service$_{ij}$, income$_i$)

Auto utility$_{ij}$ = f (highway level of service$_{ij}$, income$_{ij}$

p: probability of selecting mode *k*

Logit Model Example

Travel characteristics between two zones

Variable	Auto	Transit	Bike
a_k	-0.46	-0.07	-0.07
t_1	20	30	35
t_2	8	6	0
c	320	100	0

U_{auto} = -0.46 – 0.35(20) – 0.08(8) – 0.005(320) = **-9.70**

$U_{transit}$ = -0.07 – 0.35(30) – 0.08(6) – 0.005(100) = **-11.55**

U_{bike} = -0.07 – 0.35(35) – 0.08(0) – 0.005(0) = **-12.32**

$U_{auto} = -9.70$, $U_{transit} = -11.55$, $U_{bike} = -12.32$

Notice that auto lost share even though its "utility" stayed the same

Logit Model:

$$p(\textit{auto}) = \frac{e^{Ua}}{e^{Ua} + e^{Ut} + e^{Ub}} = \frac{e^{-9.70}}{e^{-9.70} + e^{-11.55} + e^{-12.32}} = 0.81$$

$$p(\textit{transit}) = \frac{e^{Ut}}{e^{Ua} + e^{Ut} + e^{Ub}} = \frac{e^{-11.55}}{e^{-9.70} + e^{-11.55} + e^{-12.32}} = 0.13$$

$$p(\textit{bike}) = \frac{e^{Ut}}{e^{Ua} + e^{Ut} + e^{Ub}} = \frac{e^{-11.55}}{e^{-9.70} + e^{-11.55} + e^{-12.32}} = 0.06$$

Example:

The calibrated utility functions for auto and transit travel

Auto: $V_a = - 0.3 - 0.04 X - 0.1 Y - 0.03C$

Transit: $V_t = - 0.04X - 0.1 Y - 0.03C$

where:

V_i = utility function of mode i

X = in-vehicle travel time

Y = out-of-vehicle travel time

C = cost of travel/income

A traffic zone has the following characteristics:

	Auto Travel	Transit Travel
In-vehicle time (min)	15	40
Out-of-vehicle time (min)	5	10
Travel cost (cents)	300	75

What is the probability that a person with an income of $10,000 will travel by transit?

V_a = - 0.3 – 0.05(15) – 0.1(5) – 0.03(300/10000) = - 1.4
V_t = - 0.04(40) – 0.1(10) – 0.03(75/10000) = - 2.6

Therefore, the probability of the trip maker taking transit is

$$P_i = \frac{e^{V_{(i)}}}{\sum_{r=1}^{n} e^{V_{(r)}}} =$$

$$P_t = \frac{e^{-2.6}}{e^{-2.6} + e^{-1.4}} = 0.23$$

or P_t = 23%

Example:

A calibrated utility function for travel in a medium-sized city by automobile, bus, and light rail is

$$U = a - 0.002X_1 - 0.05X_2$$

where X_1 is the cost of travel (cents), and X_2 is the travel time (min). Calculate the modal split for the given values.

Mode	a	X_1	X_2
Automobile	- 0.30	130	25
Bus	- 0.35	75	35
Light rail	- 0.40	90	40

If a parking fee of $1.00 per trip is imposed, what would be the split to the other two modes?

Solution:

Automobile: U_a = - 0.30 – 0.002(130) – 0.05(25) = - 1.81

Bus: U_b = - 0.35 – 0.002(75) – 0.05(35) = - 2.25

Light rail: U_l = - 0.40 – 0.002(90) – 0.05(40) = - 2.58

$$P_i = \frac{e^{V_{(i)}}}{\sum_{r=1}^{n} e^{V_{(r)}}}$$

$$P_a = \frac{e^{-1.81}}{e^{-1.81} + e^{-2.25} + e^{-2.58}} = \frac{0.164}{0.164 + 0.105 + 0.076} = \frac{0.164}{0.345} = 0.475$$

$$P_b = \frac{e^{-2.25}}{0.345} = 0.305$$

$$P_l = \frac{e^{-2.58}}{0.345} = 0.220$$

Summary:

Mode	U	e^u	P	Percentage
Automobile	- 1.81	0.164	0.475	48
Bus	- 2.25	0.105	0.305	30
Light rail	- 2.58	0.076	0.220	22
Total		0.345	1.000	100

If a parking fee of $1.00 per trip is imposed, U_a = would be – 0.3 – 0.002(230) – 1.25 = - 2.01.

Mode	U	e^u	P	Percentage
Automobile	- 2.01	0.134	0.425	43
Bus	- 2.25	0.105	0.333	33
Light rail	- 2.58	0.076	0.242	24
Total		0.315	1.000	100

Hence, even a flat parking of $1.00 makes a 5% difference in automobile ridership.