Technische Universität Berlin

How to Predict Mobility Behaviors of Citizens

Dr. Hamid Mostofi

mostofidarbani@tu-berlin.de

First Question:

By constructing new roads or increase road capacity of cities , Could we solve traffic congestion ?

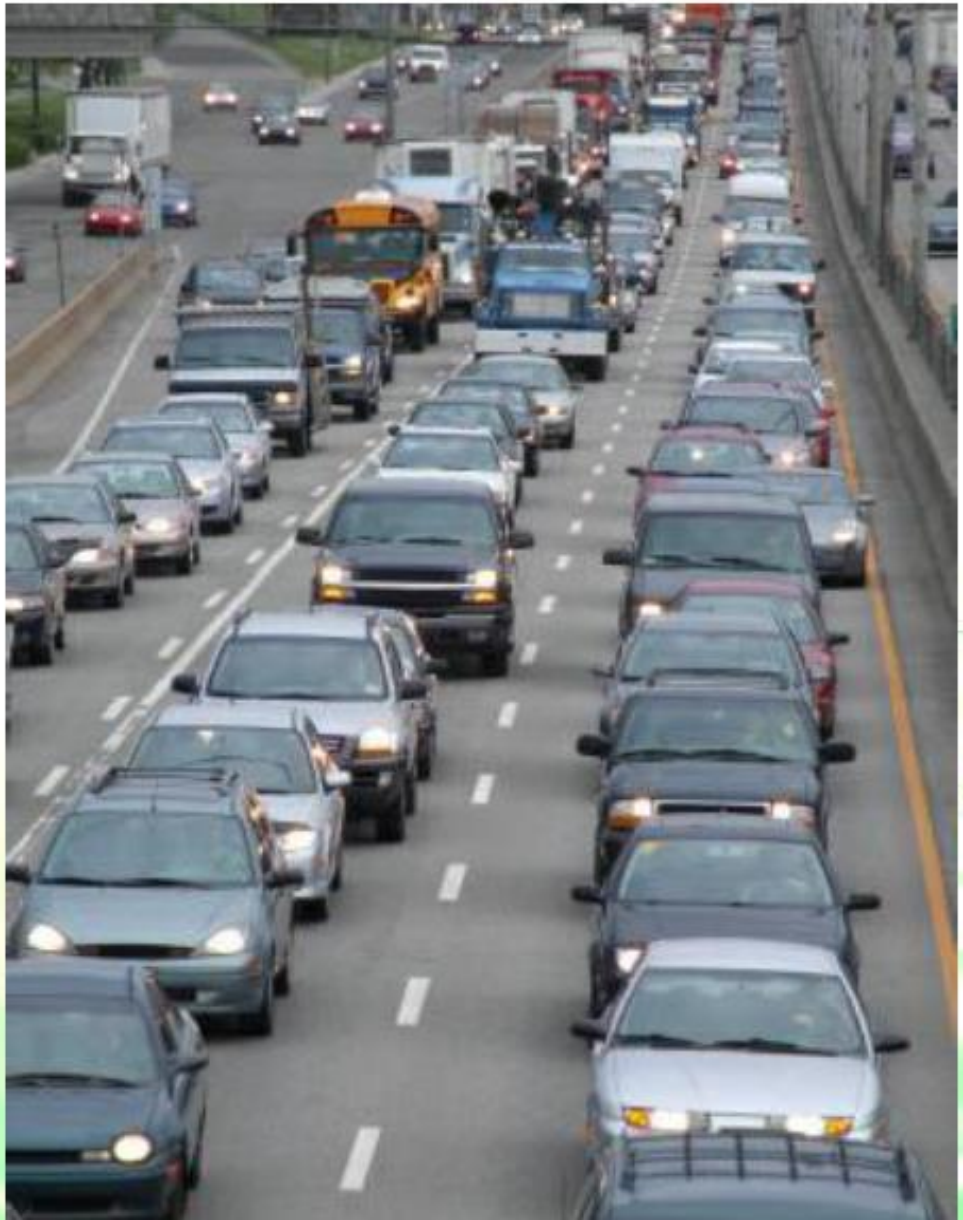
Case Study

In 1995-1996, I-10 from the Phoenix airport to Queen Creek in Arizona

Reopen with Six Lanes

Six Months Later

Congestion returned with a vengeance



The Law of Demand

Transportation can be viewed as a normal consumer good

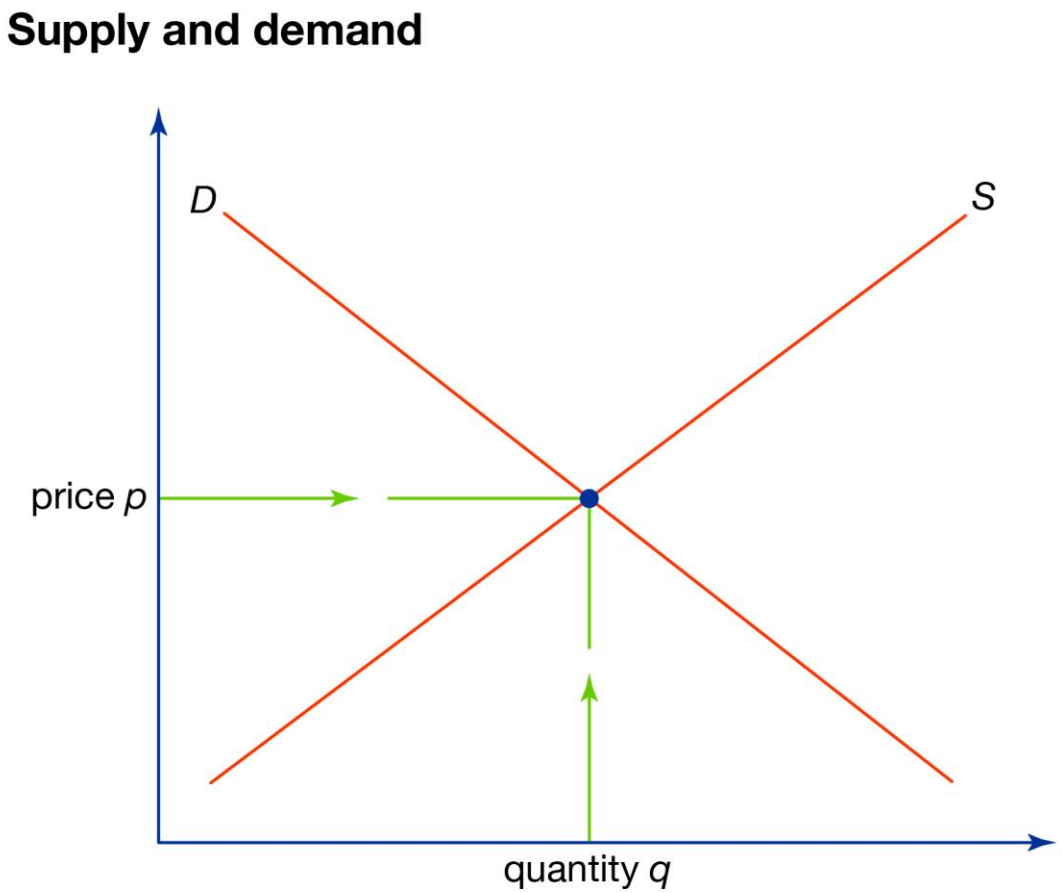
For example, the demand for car trips:

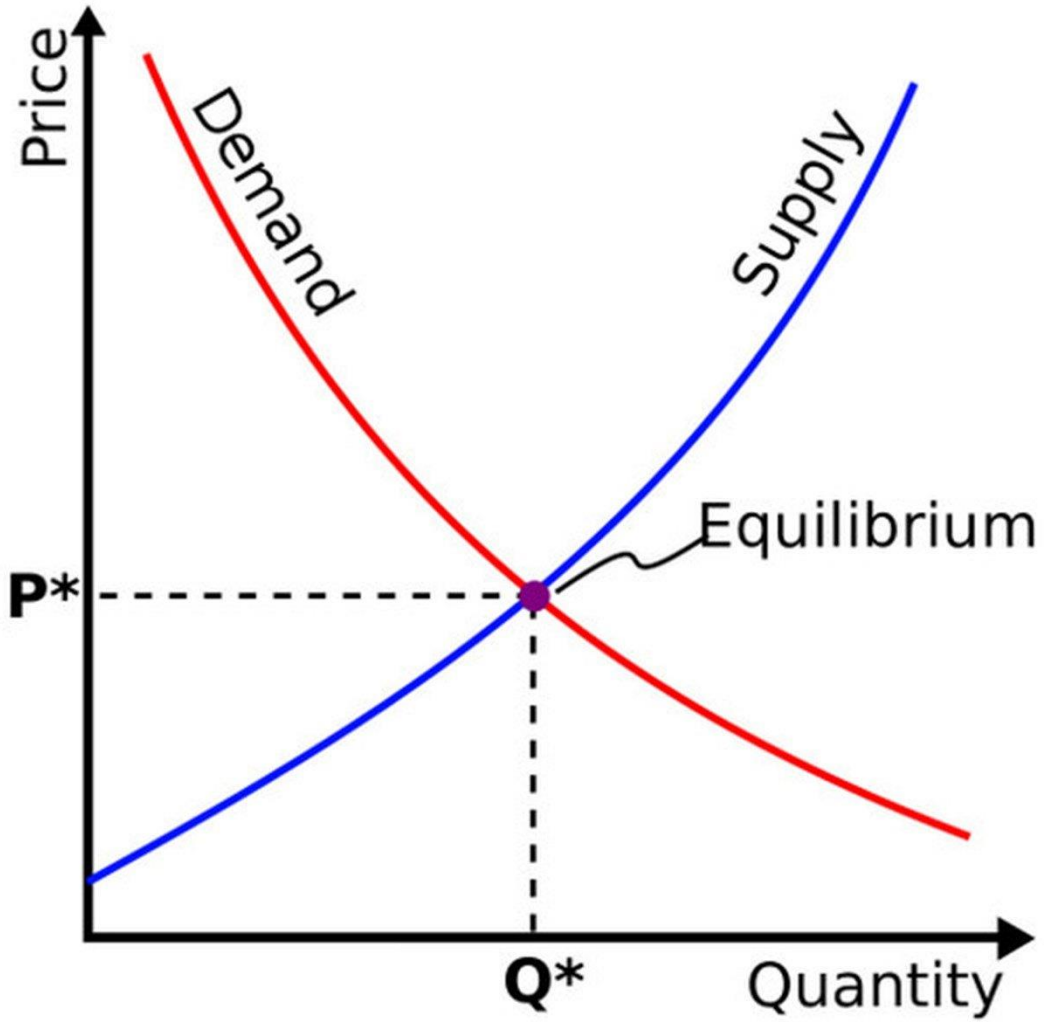
- Goes up (down) when the real price of car travel falls (increases)
- Goes up (down) when the real price of substitutes (e.g. bus travel) increases (falls)
- Goes up (down) when real income increases (falls)

The Law of Supply

- If the price of transport increases (decreases), supply of transport will increase (decrease)
- If input prices increase (decrease), the supply of transport will decrease (increase)
- Technological advances and government support may be expected to increase supply

Supply Demand Curves





“If you build them, they will come!”

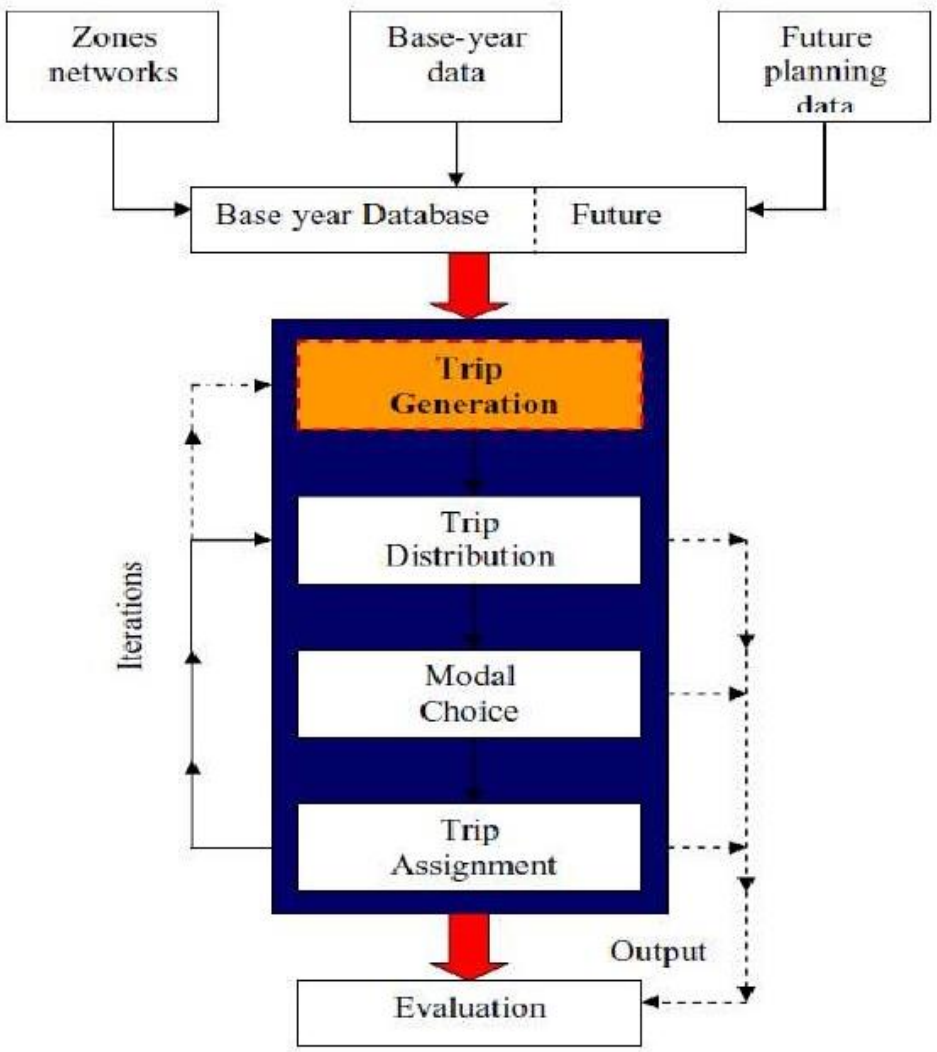
Heavy traffic in Beijing

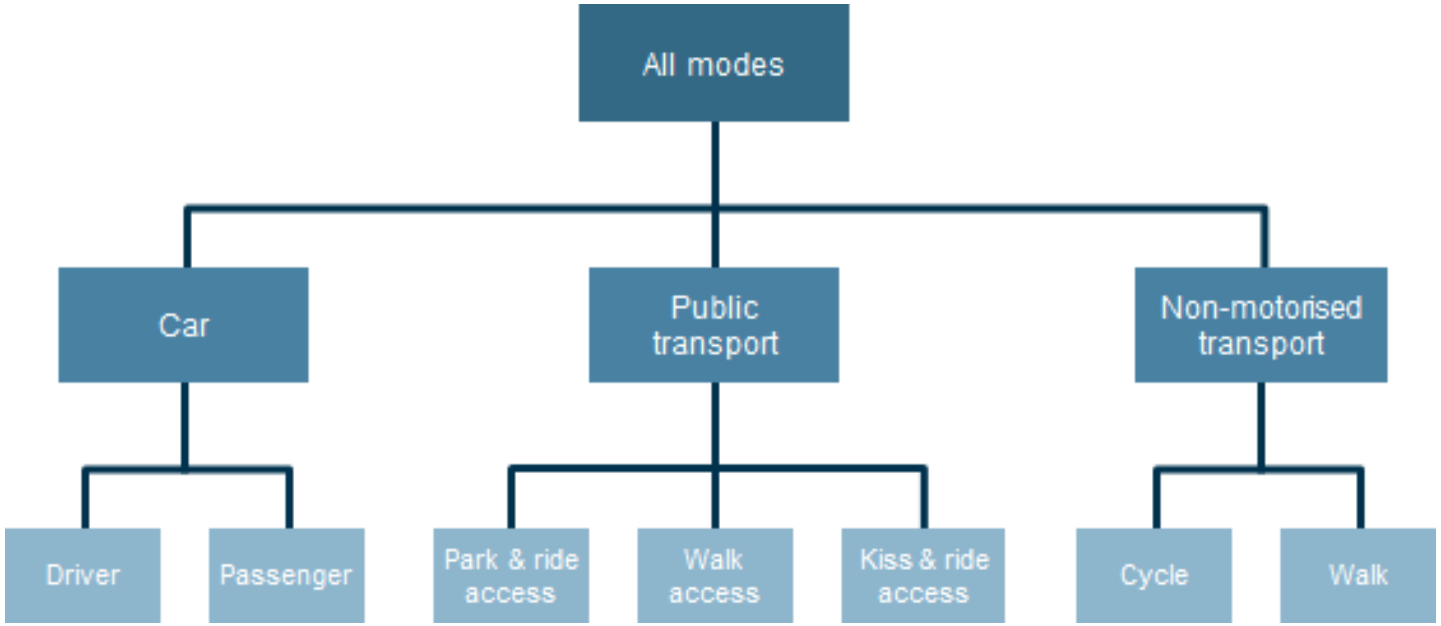
https://youtu.be/yUEHWhO_HdY

Mode Choice Analysis

- Mode choice models are used to analyze and predict the choices that customers or groups of customers make in selecting the transportation modes that are used for particular types of trips.
- A numerical method to describe how people choose among competing alternatives among of different Modes of Transportation
- Highly dependent on characteristics of modes and trip purposes
- Typically, the goal is to predict the share or absolute number of trips made by mode

Mode choice analysis





Four-Step Transportation Forecasting Process

Factors Influencing the choice of mode

- The factors may be listed under three groups:

1- Characteristics of the trip maker :

(a) car availability and/or ownership;

(b) possession of a driving license;

(c) household structure (young couple, couple with children, retired people etc.);

(d) income;

(e) Residential density

Factors Influencing the choice of mode

2- Characteristics of the journey:

(a) The trip purpose; for example, the journey to work is normally easier to undertake by public transport than other journeys because of its regularity and the possible adjustment in the long run;

(b) Time of the day when the journey is undertaken. Late trips are more difficult to accommodate by public transport.

Factors Influencing the choice of mode

3- Characteristics of the transport facility:

- There are two types of factors. 1- Quantitative 2-Qualitative.
- Quantitative factors are:

(a) Relative travel time: in-vehicle, waiting and walking times by each mode;

(b) Relative monetary costs (fares, fuel and direct costs);

(c) Availability and cost of parking

- Qualitative factors which are less easy to measure are:

(a) Comfort and convenience (b) reliability and regularity (c) protection, security

Mode Split or Modal Choice Models

- **Contemporary models are based on using UTILITY or DISUTILITY functions**
- **These functions are meant to express the level of satisfaction (for utility functions) or dissatisfaction (for disutility functions) with a given mode**
- **Once the utility function is calculated for each mode, the probability that a given mode will be chosen can then be calculated**

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

A utility function takes the following form

$$u_k = a_k + a_1 X_1 + a_2 X_2 + \ldots\ldots a_r X_r + \varepsilon_0$$

Where

u_k – utility function for mode k

a_k – modal constant

X_r – variables measuring modal attributes such as cost or time of travel

a_r – coefficient associated with each attribute

ε_0 – error term

Logit Models

- Calculates the probability of selecting a particular mode

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

p: probability of selecting mode *k*

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$_{ij}$

The Multinomial Logit Model is used to calculate the probability that a traveler will chose a given mode

The Logit Model

- The Logit Model, widely used for in transportation forecasting in various forms to calculate the probability of a certain mode choice.

Steps for the Logit Model:

•Calculate the Utility for each mode
•Calculate Exponentiated utilities for each mode
•Sum Exponentiated utilities for each OD pair
•Calculate Probability for each mode by OD pair
•Multiply Probability by number of trips

$$P_{iq} = \frac{\exp(\beta V_{iq})}{\sum_{A_j \in A(q)} \exp(\beta V_{jp})}$$

Car utility (Taxi and Private car) = F (Average Cost car trip, Average car trip time, Car ownership)

Public transport utility (Bus, LRT) = F (Average time of PT, Average cost of PT, Waiting time, PT Accessibility)

Logit Model Example

Utility functions for auto and transit

$U = a_k - 0.35t_1 - 0.08t_2 - 0.005c$

a_k = mode specific variable

t_1 = total travel time (minutes)

t_2 = waiting time (minutes)

c = cost (cents)

Logit Model Example

Travel characteristics between two zones

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

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

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

Logit Model Example

$U_{auto} = -9.70$

$U_{transit} = -11.55$

Logit Model:

$$p(auto) = \frac{e^{Ua}}{e^{Ua} + e^{Ut}} = \frac{e^{-9.70}}{e^{-9.70} + e^{-11.55}} = \underline{0.86}$$

$$p(transit) = \frac{e^{Ut}}{e^{Ua} + e^{Ut}} = \frac{e^{-11.55}}{e^{-9.70} + e^{-11.55}} = \underline{0.14}$$