Final Sir

Lecture-01:

08.05.24

Household travel survey:

V.V.I → 4 step model: → mostly used → খারাপ দিক → Private car কে প্রাধান্য দেয়া হয়েছে বেশি.

(1) Trip generation
(2) Trip distribution
(3) Mode choice
(4) traffic assignment

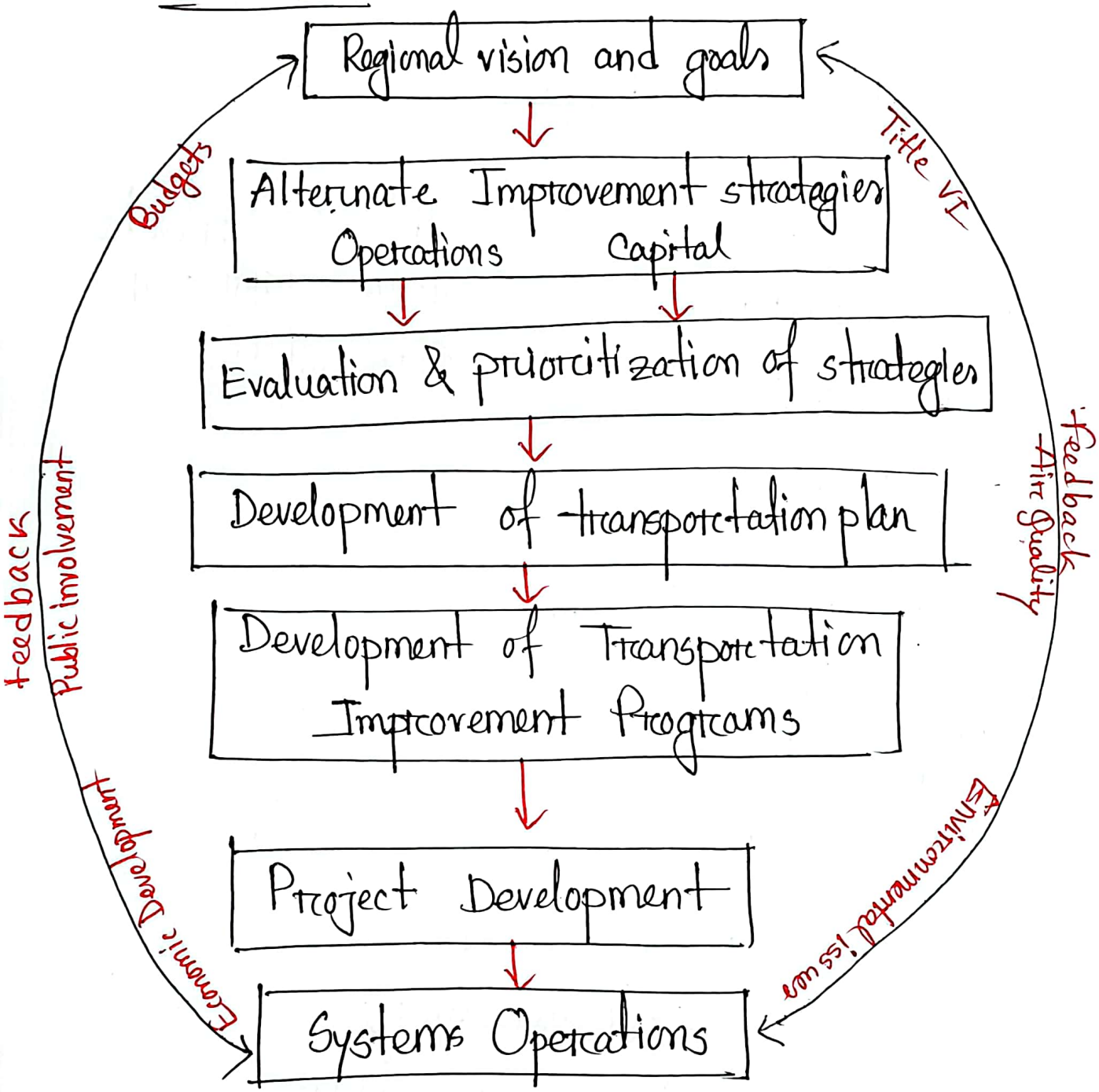
Transportation issue:

- today → (1) drainage (Slide-এ নাই)
- future → (1) shared mobility (pathao, uber)
(11) Autonomous vehicles (tesla)

V.V.I → Transportation planning process: (flow chart)

- STP → Strategic Transport plan for Dhaka
→ Search দিলে এটা thesis paper পাবো এটা বুঝতে হবে, RSTP-A-Comprehensive-stu

flow chart:



Transportation planning process

Lecture-02:

23.05.24

- peak hour এর মধ্যে কতগুলো গাড়ি চলাচল করছে।
  সকাল (7-8)টা
  বিকাল (5-6)টা
- peak hour flow বের করে future-এ demand কতহতে পারে তা বের করতে হবে।

Data Collection:

- Traffic analysis zone (TAZ)
- Transportation network
- Data collection process

Traffic analysis zone (TAZ):

- study areas are usually divided into analysis units referred to as Traffic Analysis zone.
  → Unit এমনভাবে যাতে সবার socioeconomic status same.
- Units depend on → (parameters)

	Zone #1 (100 HHs)	Zone #2 (Kalshi
① household size →	(4) ↳ Unit 1	(5+) ↳ Unit 2
② household income (monthly) →	1 lac	30000
③ Vehicle ownership →	1+	0

④ Political boundary
↳ কখনো ward/ মিলে TAZ হতে পারে

- inter zonal trip → minimized হবে এমন ভাবে zone select করবে।

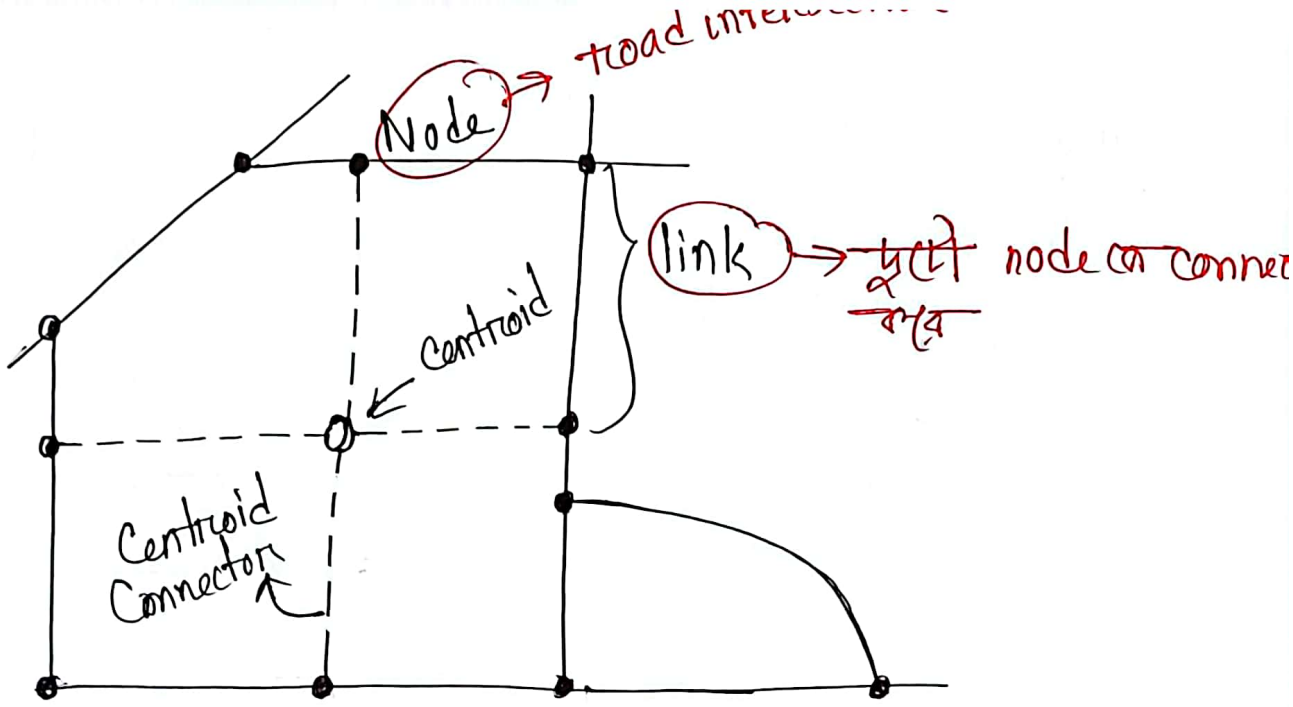
- CBD area → Central Business District

Criteria used to define TAZ:

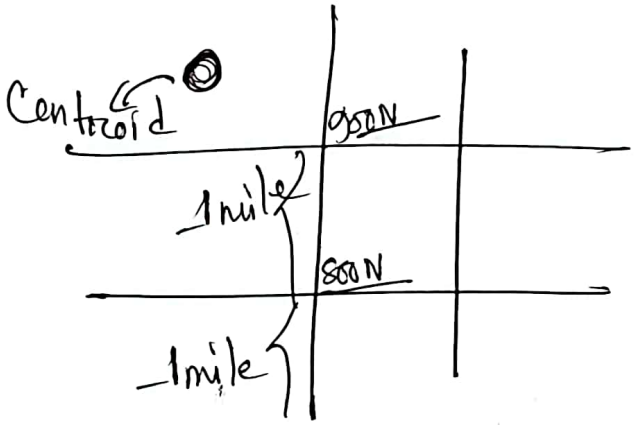
- homogeneous socioeconomic characteristics for zone's population.
- Basing zonal boundaries on census zone.

Transportation network:

- Consist of →
  1. Roads
  2. Rail lines
  3. Dedicated bus lines
  4. Inland waterways .ie. navigable rivers, canals etc.



- 1 mile করে block থাকবে যার ভিতরে residential/ commercial area থাকবে। একটা centroid থাকতে হবে



Data collection :

Sampling method →

Types :

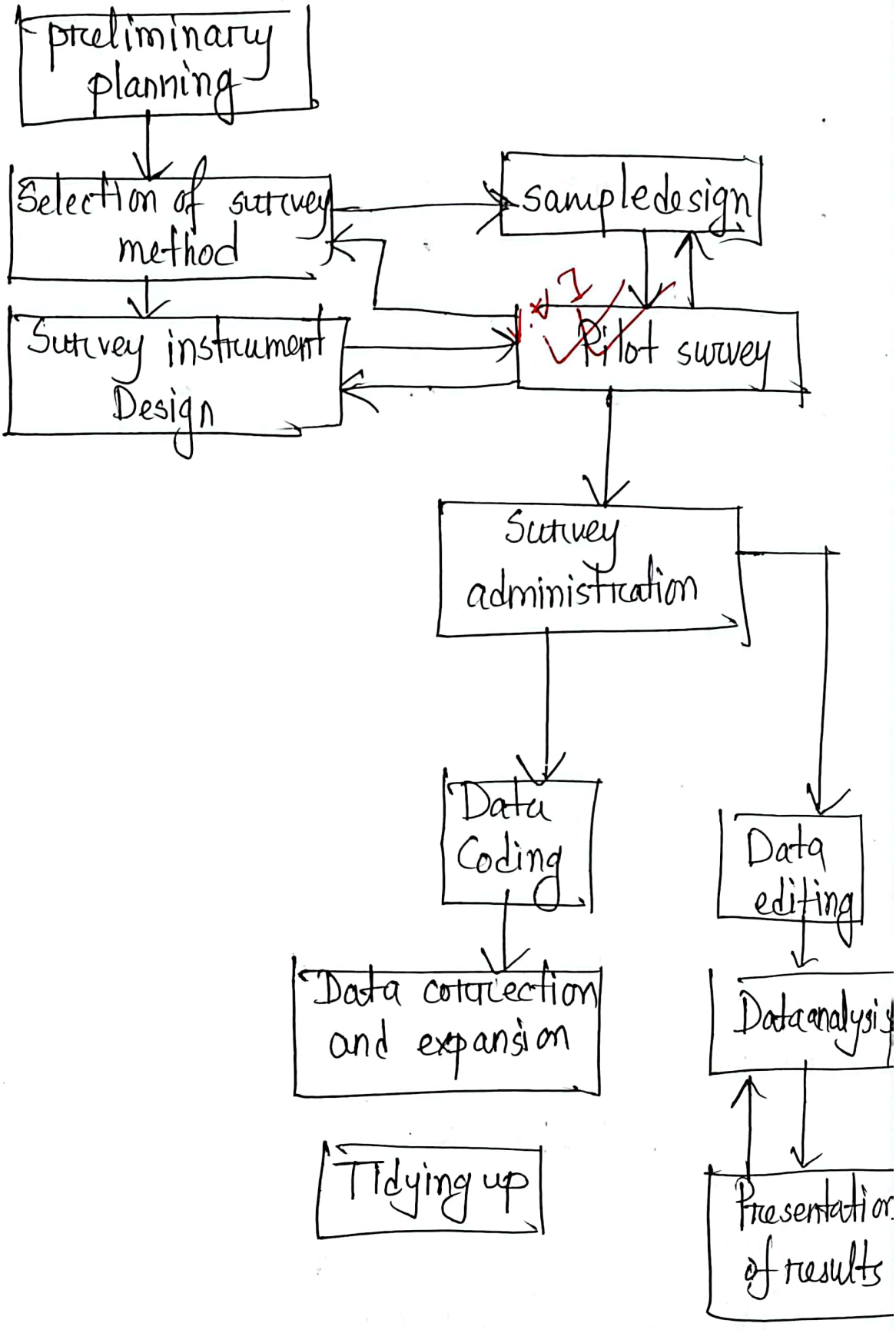
① Random sampling

② Stratified sampling → কিছু নির্দিষ্ট মানুষের থেকে sample data নিবো

③ Convenience "

transit data analysis

Survey method summary :



Types of data: → for road network

- Traffic count data
- Cordon count data
- Screen line count data
- vehicle classification
- Truck weight data
- Speed data collection
  - → Spot speed → instantaneous speed
  - → Moving vehicle method → avg speed

transit related problem, topic বাদ

Lecture-03:

30.05.24

skip this topic

Types of data: Transportation system (2) → for transit design

- List of transit companies and/or operating agencies.
- Total number and type of transit vehicles
- Transit routes by type of service
- Total number of miles of routes by type and company.
- Route number, description and terminal to terminal mileage.

Traveler characteristics:

- How used →
  1. Validation of existing models
  2. Develop new models
  3. Monitor air and environmental quality
  4. Support corridor and traffic studies

Household travel survey:

- Format of the survey →
  - Home interview
  - Phone "
  - Mail back survey
- Temporal dimension →
  - Cross-sectional (10 বছর পরপর) — random stratified survey
  - Panel survey — একটা group of people কে select করে কয়েক বছর পরপর data collect করে।

Revealed preference survey:

↳ structure exist না

- Survey that captures the prevailing behaviour.
- Design considerations are much less technical than that of stated preference.

Stated preference survey: (SP survey)

↳ structure exist করে

- Need very careful design of choice experiment
- Choice alternatives are presented in terms of attributes
- The levels of the attributes need to be selected very carefully.

Choice experiment → SP survey

Option 1: MRT

TT (Travel time), 15 min → levels

TC (Travel cost), 50 Tk → levels

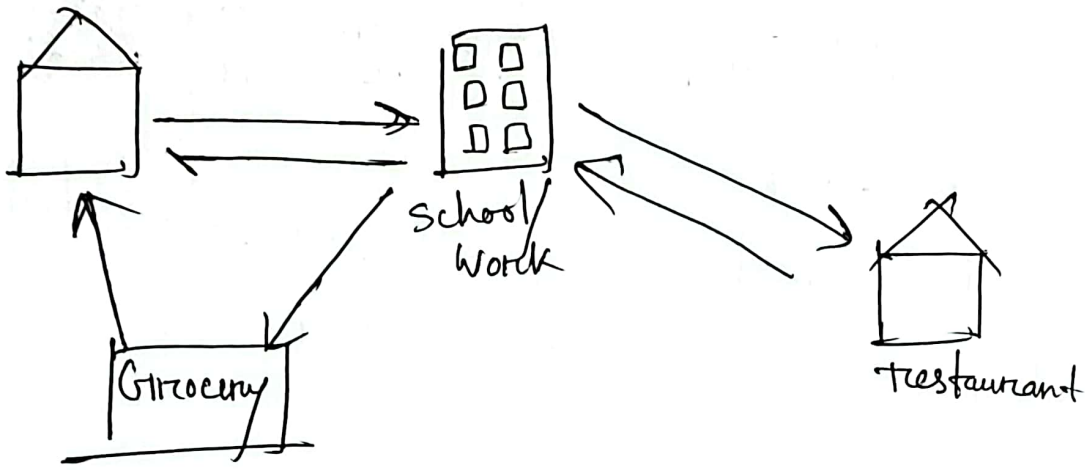
Option-2: Personal car

TT, 10 min → levels

TC, 100 tk → levels

attributes

Revealed Preference survey:



- Attitudinal survey example

- pedestrian survey → মানুষের মতামত। (other types of survey)

Lecture-04: 06.06.24

Trip generation:

Two approaches to trip generation:

① Individual site/development → ITE generation manual

② Regional/zonal trips produced/attracted → travel demand forecasting models.

(*) How many trips come to and leave from a particular establishment?

⇒ (i) by time of day
(ii) by (mode)

non-linear → slop same না

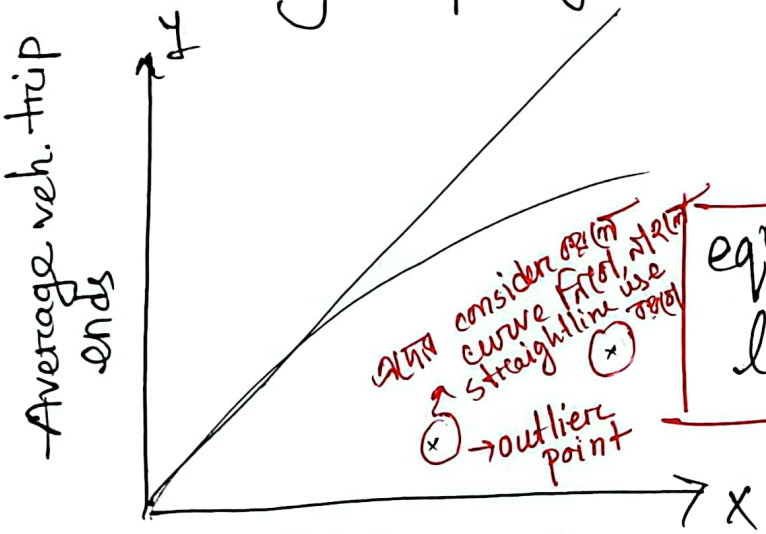
TAZ → Traffic Analysis Zone

Example :

Avg rate	Range of rates	Standard deviation
8.11	1.78 - 24.95	5.85

- USU proposed engg. research building at innovation campus → 4 stories, (200'x100') floor

- How many trips generated → Using avg rate?
  → Using fitted curve



eqn of fitted curve,
$\ln(T) = 0.82 \ln x + 3.14$

number of studies > 20

per 1000 sq. feet gross floor area →
→ Value of X

গাড়ি বেশি হলে accident বেশি কিন্তু গাড়ি খুব বেশি হলে accident কম হবে → এটা non-linear relation

Method-1 : Avg rate method

avg trip rate = 8.11

4 stories x (200' x 100'/story)
= 4 x 200 x 100 = 80000 sq. ft

$\therefore X = \frac{80000}{1000} = 80$

$\therefore$ trip = 8.11 x 80 (Avg trip rate x value of (X))
= 648.8 ≃ 649 vehicle trip ends (for curve)

Method-2 ; Equation

$\ln(\text{Trips}) = 0.82 \ln(x) + 3.14$, where x in 1000 sq.ft gross floor area.

$x = 80(1000 \text{ sq.ft})$

যেকোনো কিছুর সামনে ln বসানো মানে straight line বানানো।

$\text{Trips} = \exp(0.82 \ln(80) + 3.14)$

$= \exp(3.59 + 3.14) = \exp(6.73)$

$= 839.86 \approx 840$ (for straight line)

↳ higher roundup

- We should select 840 between 840 and 649 because higher trips are safer for design.

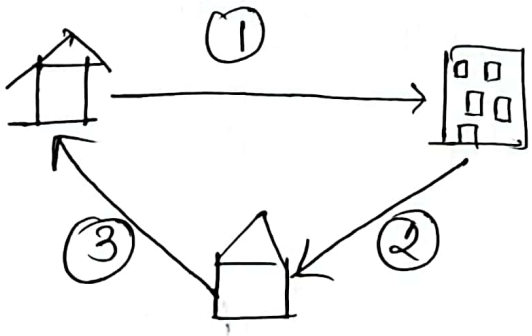
Trip generation – data collection ;

xm-2 আলোচনা

- 24 hours for 7 day ; 24-48 hours week day, or 2 hour

Transportation model : (4-step)

- Trip generation
- Trip distribution
- Mode choice
- Traffic assignment



Trip based :

1. Home based work trip (HBW)
2. Non-home based restaurant trip (NHR)
3. Home based

Trip যাত্রা শুরু এবং শেষে home
থাকলে home based বলে

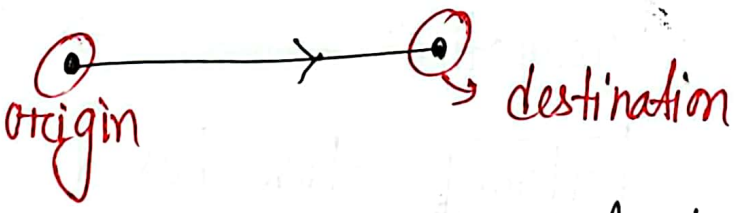
Lecture - 05 : 27.06.24

Supplementary Document - 1 এসাইন্মেন্ট

Trip generation : ২ভাবে ভাগ করা যায় →

(i) Individual site - এ কী পরিমাণ trip generate
(ii) Zonal level (TAZ)

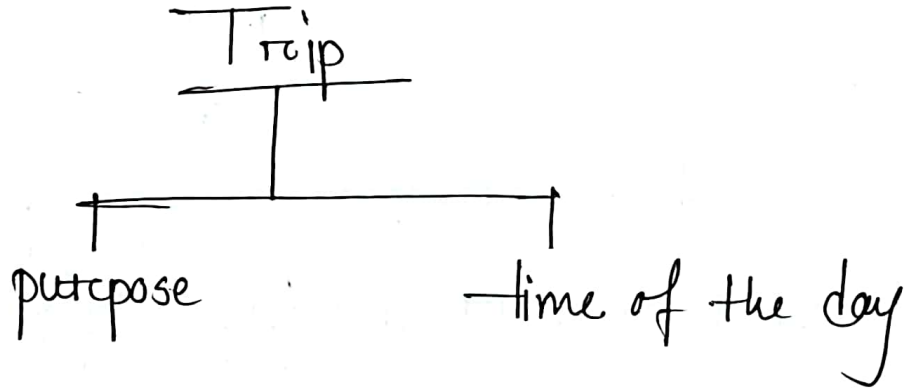
Definition :



① Trip end → the two end points of a trip

(2) Trip Production → Where the need/desire for a trip is demanded

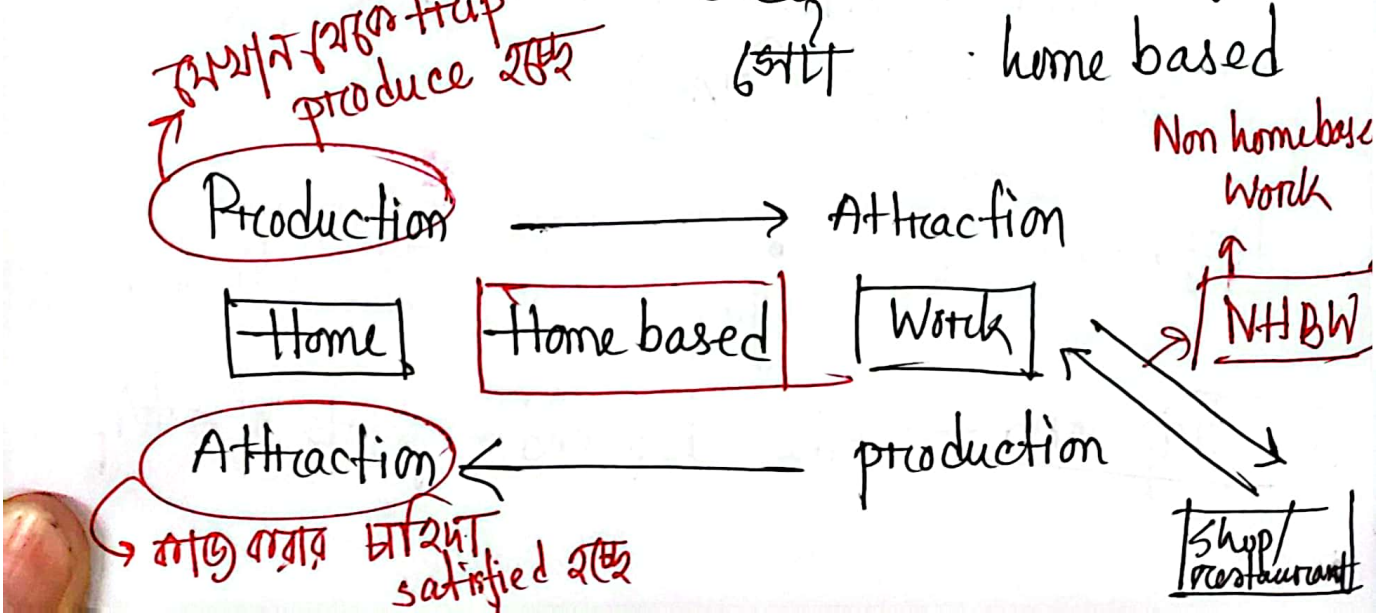
(3) Trip attraction → Where the need/desire for a trip is satisfied.

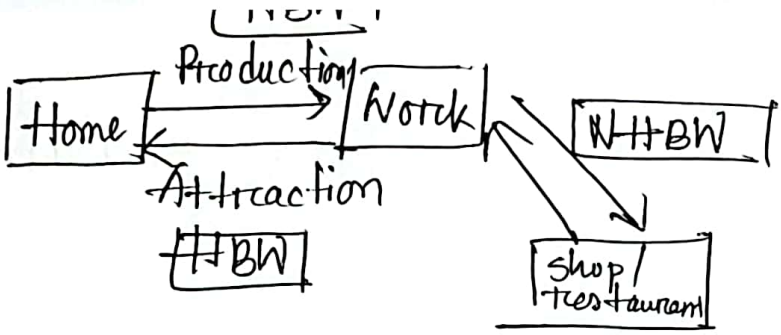


PA → Production & Attractions
OD → Origin & Destination

Trip purpose → classification

(1) Home based → production/attraction side-এ home থাকবে তাই home based





Trip generation in travel demand models:

- Trip productions → Cross-classifications
  - Characterize household by 1+ attribu
  - Calculate avg trip rate for each household type (from HHTS)
  - Multiply # households by type by average trip rate & sum.

Household travel survey

- Trip attractions → Linear equation
  - Estimate a linear regression model on destination attributes (from HHTS)
  - Characterize amount of activity in each zone
  - Plug amounts into linear eqn and c ulate.

(*) What factors affect trip generation rates?

⇒ Trip productions → household
people
Workers
Children
Vehicles
household income

Trip attractions → no of shops
recreation
Job (employment)

Example : Trip productions ;

↳ zone analysis zone - 1 হল zone.

TAZ 123 has →

50 HHs with 0 workers

HBW Trip productions = Trip rate X no of HH having workers

Trip attractions :

→ xm-2 linear eqn develop করতে দিবেনা। eqn দিয়েদিবে

TAZ 123 has →

400 HH

600 jobs → 200 govt. job
400 office "

attraction rate →

HBW : 1.25 trips / job

HBSocial: 0.9 trips / office job + 0.25 trips / govt. job + 0.30 trips / HH

∴ HBW = 1.25 × 600 = 750

HBSocial = 0.9 × 400 + 0.25 × 200 + 0.30 × 600

Supplementary Document এ ans আছে

Previous year Ques

1. What factors affect trip generation rates?
2. Are trips rates stable? Across time? Between regions?
3. What would happen to trip generation rates with → @ Rise in e-commerce?

(b) Drone-based deliveries?
(c) New out-of-home activities?
(d) Autonomous vehicles?
(e) Virtual reality in the home?

VTT → Value of Travel Time
→ VTT বাড়লে autonomous veh বাড়বে.

Lecture-06 : 04.07.24

Trip distribution :

Trip based models →

(I) Generation
(II) Distribution
(III) Mode choice
(N) Assignment



একটা zone থেকে আরেকটা zone-এ কয়টা trip develop হবে।

- matrix ২প্রকার →

(i) PA → Production - Attraction

(ii) OD → Origin-Destination

Notation ; 1. TAZ = Traffic analyses zone

2. i = production zone

3. j = attraction zone

4. A_1 = zone 1-এ total attracted trip

5. P_1 = zone 1-এ total produced trip

6. $\vec{i}_1$ = production zone 1

7. $\vec{j}_1$ = attraction zone 1

8. T = Trip ; 9. TT = Travel Time

Constraints;

(i) Row sum should equal trip productions

$$\sum T_{ij} = P_i$$

(ii) Column sum should equal trip attractions

$$\sum T_{ij} = A_j$$

Singly constraints: If only one of these conditions (usually P) holds.

- Production year-এ Production constant থাকা

Doubly constraints: যদি attraction এবং production দুটোই constant থাকা হয়।

LOS (Level of service):

- 6 types

(*) What do you consider when you choose a destination?

⇒ বাধা
- Impedance / LOS → যেখানে যাবে সেখানে travel কেমন
  - Travel time or (generalized) cost
- Attractiveness → কোনো জায়গায় যাওয়ার সুবিধা কী?
  - ~~#~~trip attractions
  - Employment by type

Trip distribution methods : (3 models)

(1) Growth factor model → Fratar / Furness method
→ Iterative fitting of growth factors

(2) Gravity model → Calibration → friction factor
→ Application
↳ newton এর 2nd law অনুযায়ী করা হয়েছে

(3)

Growth factor model:

Simple:

- Base year PA trip matrix from survey data
- Uniform area-wide growth of 20 %.
  ($\gamma = 1.20$)

Base year

P \ A	z_1	z_2	z_3	Total
z_1	5	50	95	
z_2	95	5	100	
z_3	50	95	5	
Total				

Forecast year

$$T_{ij}' = \gamma \times T_{ij}$$

- T_{ij}' → forecast trip
- γ → Growth factor
- T_{ij} → base year trip

* Base year matrix দিয়ে দিবে always

Singly constrained :

- forecast year এর একটা goal দিয়ে দিবে তখন zone-1 এ কত trip generate হবে তা বের করতে হবে।

- first-এ growth factor বের করবো, then base year এর সাথে গুণ করে forecast year বের করবো

Base year

P \ A	Z_1	Z_2	Z_3	Total	T_i
Z_1	5	50	95	150	
Z_2	45	5	100	150	
Z_3				150	
Total					

forecast year

P \ A	Z_1	Z_2	Z_3	Goal
Z_1	6	60	114	180
Z_2	49.5	5.5	110	165
Z_3				255
Total				

roundup করতে হবেনা, যেভাবে আছে সেভাবে থাকবে

Growth factor

$T_1 = \frac{180}{150}$

$= 1.2$

$T_2 = \frac{165}{150} = 1.1$

Doubly constrained :

- Base year এবং forecast year এর জন্য Iterative method use করতে হবে।
- আমরা base year এবং forecast year দুটোতে goal দিয়ে দিবো।

Base year

P \ A	z_1	z_2	z_3	Total	Goal	Σ_i
z_1	5	50	95	150	180	1.2
z_2	45	5	100	150	165	1.1
z_3	50	95	5	150	255	1.7
Total	100	150	200	600		
Goal	195	165	240			

- বারবার iteration করে বের করতে হবে।
- Growth factor প্রথমে production end এর Σ_i বের করে iteration (1) করবো then changed attraction থেকে attraction end-এ Growth factor বের করে iteration (2) করবো তারপর production end change হবে, তখন আবার production end-এ Growth rate বের করে আবার iteration (3) করবো।

- দুই পাশের Growth factor 1 এর কাছাকাছি হলে iteration stop করতে।

$$|T_j - 1| < 0.01 \text{ or } 0.001$$

Iteration step বলে দিবে

Growth factor model:

Advantage:

- Simple
- No impedance/LOS info needed

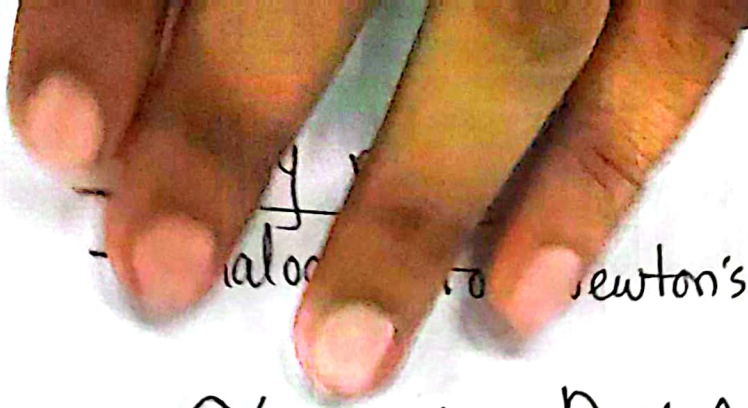
Disadvantage:

- No volumes to and from new zones
- Not good for looking at policy effects
- Ignores congestion (and any LOS)

forecast year (1)

P \ A	z_1	z_2	z_3	Total
z_1	6	60	114	180
z_2	49.5	5.5	110	165
z_3	85	161.5	8.5	255
Total	140.5	227	232.5	
Gro				

forecast year (2)



- ...alo... ...ewton's law of gravity

$$T_{ij} = \alpha \times P_i \times A_j \div (d_{ij})^2$$

- Directly proportional to
  - Trips P_i Produced in zone i
  - " A_j attracted to zone j

- Inversely proportional to
  - impedance d_{ij} between zones i and j

friction factor → derivation লাগবেনা

d_{ij} = distance

P_i = Production

A_j = Attraction

α_{ij} = production ও attraction end factor

- distance যত বাড়বে traveling time এবং cost দুটোই বাড়বে

Gravity model :

- analogus to Newton's law of gravity

$$T_{ij} = \alpha \times P_i \times A_j \div (d_{ij})^2$$

- Directly proportional to
  - Trips P_i Produced in zone i
  - " A_j attracted to zone j

- Inversely proportional to
  - impedance d_{ij} between zones i and j

friction factor → derivation লাগবেনা

d_{ij} = distance

P_i = Production

A_j = Attraction

α_{ij} = production ও attraction end factor

- distance যত বাড়বে travel ing time এবং cost দুটোই বাড়বে

- Travel time হিসেবে d_{ij} কে প্রকাশ করা হয়।

$$\text{cost function} = f(c_{ij})$$

friction factor :

(i) parametric → mathematical relation following

(ii) Non parametric

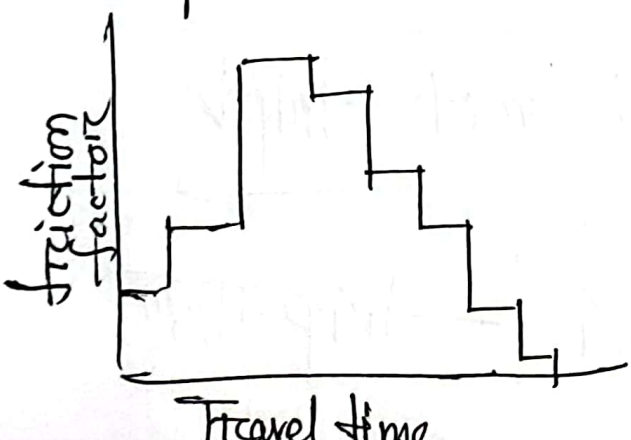
parametric (mathematical eqn) →

(i) power $f(c_{ij}) = f_{ij} = (c_{ij})^{y}$

(ii) Exponential $f(c_{ij}) = f_{ij} = \exp(z \times c_{ij})$

(iii) Gamma $f(c_{ij}) = f_{ij} = \kappa \times (c_{ij})^{y} \times \exp(z \times c_{ij})$

Nonparametric (look-up table) →



$$f_{ij} = \begin{cases} f_1 & \text{if } 0 \le t_{ij} \le 5 \\ f_2 & \text{if } 5 \le t_{ij} \le 10 \\ f_7 & \text{if } 30 \le t_{ij} \le 35 \end{cases}$$

friction factor বা congestion factor ব্যবহার করা হলো

Lecture-07:

10.07.24

Gravity Model calibration: (Doubly Constrained)

- Travel time ⟶ impedance

- Given ⟶

  - Initial PA matrix (T_{ij}, P_i, A_j)

  - Generalized cost (or impedance) matrix

trip production change হলে আগের

Base year

P \ A	z_1	z_2	z_3	y
z_1	5	50	95	150
z_2	45	5	100	150
z_3	50	95	5	150
Total	100	150	200	450

Zone 1-2 100 trip attracted

z_1 থেকে z_2 Travel time

Impedance

TT	z_1	z_2	z_3
1-10 z_1	5	16	13
11-15 z_2	16	7	20
16-20 z_3	13	20	2

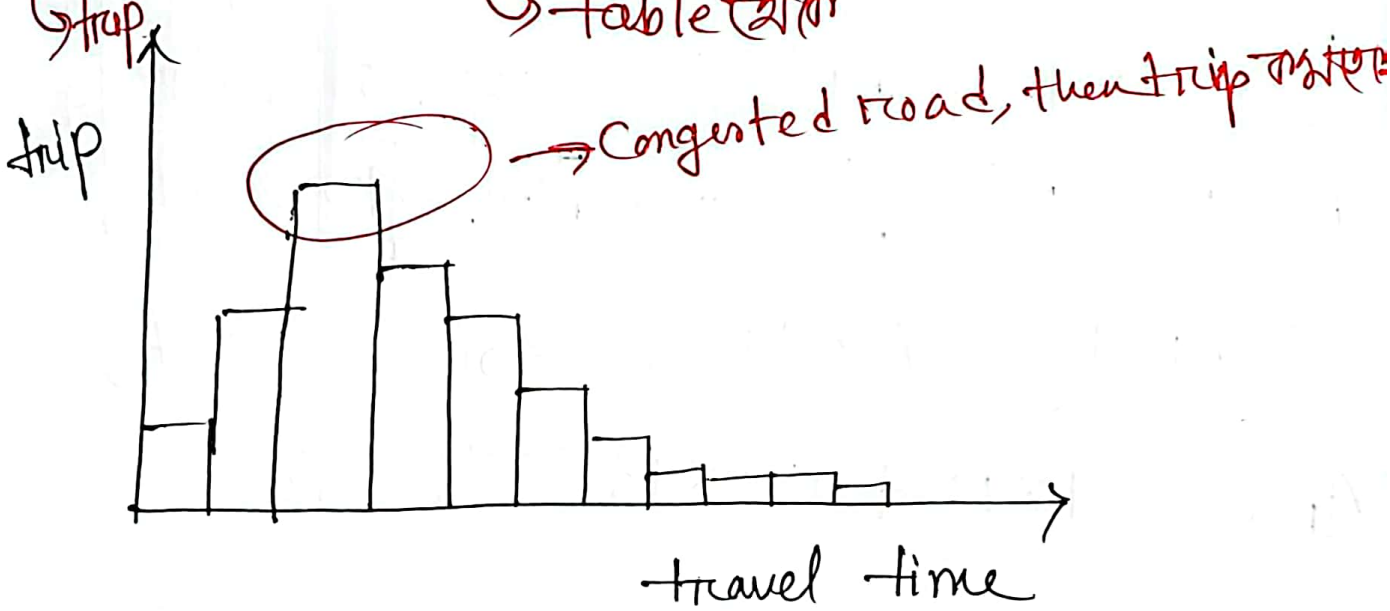
② Travel time↑ trip↓

① Trip ↑ travel time↑ — trip বাড়লে

jam বাড়লে, jam বাড়লে travel time বাড়বে,
travel time বাড়লে তখন trip আবার কমবে।

$$T_{ij} = P_i \times A_j \times f_{ij} \div \Sigma_{ij} (A_j \times f_{ij})$$

T_{ij} → trip
f_{ij} → table থেকে



- Impedance অনুযায়ী friction factore develop করবো।

Suppose, $T_{12} = P_1 \times A_2 \times f_{12} \div \Sigma_{12} (A_2 \times f_{12})$

P_1 → total production of z_1
A_2 → total production of z_2

Set up;

step ①: Determine friction factor
- Assume initially $f_{ij} = 1$
- Create f_{ij} matrix
- Calculate denominator form

Sum product $\Sigma_{ij} (A_j \times f_{ij})$ → z_1 ⇒ 100×1 + 150×1 + 200×1 = 450

- Apply formula to calculate (T_{ij})

Ff matrix (1)

TT	Z_1	Z_2	Z_3
Z_1	1	1	1
Z_2	1	1	1
Z_3	1	1	1

Base year (1)

PA	Z_1	Z_2	Z_3	Total	Σ
Z_1	33.3	50	66.7	150	450
Z_2	33.3	50	66.7	150	450
Z_3	33.3	50	66.7	150	450
Total	100	150	200	450	

$$\Sigma A_j \times f_{ij} = A_1 \times f_{11} + A_2 \times f_{12} + A_3 \times f_{13}$$

$$\Sigma A_1 \times f_{11} = 1 \times 100 + 150 \times 1 + 200 \times 1 = 450$$

$$T_{11} = P_1 \times A_1 \times f_{11} \div \Sigma A_1 \times f_{11}$$

$$= (150 \times 100 \times 1) \div 450$$

$$= 33.3$$

$$T_{13} = P_1 \times A_3 \times f_{13} \div \Sigma A_3 \times f_{13}$$

$$= (150 \times 200 \times 1) \div 450$$

$$= 66.67 \sim 66.7$$

- Calculate estimated trip length distribution
- Update friction factors, $ff_{new} = ff_{old} \times \left(\frac{Obs}{Est}\right)$
- Repeat steps ① to ⑤ until ffs don't change.

— Travel time ক trange-এ ভাগ করতে হবে।

TT	Estimated trip	Observed trip	FF
1-10	150	5+5+5 = 15	0.1
11-15	100	50+95 = 145	1.45
16-20	200	50+45+100+95 = 290	1.45

$\frac{15}{150} \times 1 = 0.1$ (new ff matrix-এ 1-10 এর জন্য বসাবে)

1-10 এ 5, 7, 2 আছে তাই এদের trip add করে পাবো estimated trip.

TT (1-10)-এ estimated trip = $T_{11} + T_{22} + T_{3}$
$= 33.3 + 50 + 66.7$
$= 150$

TT (11-15) - " " $= T_{31} + T_{13}$
$= 33.3 + 66.7$
$= 100$

TT (16-20) " " $= T_{12} + T_{21} + T_{23} + T_{32} = 50 + 33.3 + 66.7 + 50$

$f_{new} = \frac{\text{observed}}{\text{estimated}} \times f_{old}$

$$\text{friction factor} = \frac{\text{Observed}}{\text{estimated}} \times \text{old}$$

ff matrix (2)

TT	z_1	z_2	z_3
z_1	0.1	1.45	1.45
z_2	1.45	0.1	1.45
z_3	1.45	1.45	0.1

Base year (2)

P \ A	z_1	z_2	z_3	Total	Σ
z_1	2.9	63	84.1	150	517.5
z_2	48.3	5	96.7	150	450
z_3	56.9	85.3	7.8	150	382.5
Total	108.1	153.3	188.6	450	

→ Base year (1) এর 100, 150, 200 use করবো।

$\Sigma_{11} = A_1 \times f_{11} + A_2 \times f_{12} + A_3 \times f_{13}$

$= 100 \times 0.1 + 150 \times 1.45 + 200 \times 1.45$

$= 517.45$

$\Sigma_{21} = A_1 \times f_{21} + A_2 \times f_{22} + A_3 \times f_{23}$

$= 100 \times 1.45 + 150 \times 0.1 + 200 \times 1.45$

$= 450$

$\Sigma_{31} = A_1 \times f_{31} + A_2 \times f_{32} + A_3 \times f_{33}$

$= 100 \times 1.45 + 150 \times 1.45 + 200 \times 0.1$

$= 382.5$

$$T_{11} = P_1 \times A_1 \times f_{11}^{new} \div \Sigma(A_1 \times f_{11})$$

$$= (150 \times 100 \times 0.1) \div 517.5 \quad \text{new}$$

$$= 2.9$$

Base year (2) → Base year (1) এর data use করে হবে করবো।

$$T_{13} = P_1 \times A_3 \times f_{13} \div \Sigma(A_3 \times f_{13})$$

$$= (150 \times 200 \times 1.45) \div 517.5$$

$$= 84.1$$

- দুই decimal পর্যন্ত মানে / এক decimal

- যতক্ষণ না পর্যন্ত $|f_{new} - f_{old}| < 0.01$ or 0.001

হবে ততক্ষণ পর্যন্ত trial দিতে হবে।

- marks বলি আসলে trial বলবি। trial বলা হলে ques-এ বলে দিবে কত base year পর্যন্ত যাবো। Suppose, base year (2) পর্যন্ত যেতে বলবে।

Lecture-08:

16.07.24

base year এর data সংগ্রহ করা

Gravity model application : (doubly constrained)

- future এর production, attraction goal দেয়া থাকবে।
- impedance → future generalized cost দেয়া থাকবে।
- Calibrated friction factors দেয়া থাকবে।

forecast year

PA	z_1	z_2	z_3	Goal
z_1				160
z_2				165
z_3				255
Goal	195	165	240	600

বের করতে হবে

- Impedance

TT	z_1	z_2	z_3
z_1	7	18	16
z_2	18	11	20
z_3	16	20	5

friction factors

TT	Est	Obs	ff
1-10	15	15	0.1
11-15	145	145	1.51
16-20	290	290	1.43

- friction factor matrix বের করতে হবে।

Step 1: Develop FF matrix

FF matrix

TT	z_1	z_2	z_3
z_1	0.1	1.43	1.43
z_2	1.43	1.51	1.43
z_3	1.43	1.43	0.1

→ 1-10 TT range - এ 0.1

forecast year (1)

P \ A	z_1	z_2	z_3	Goal	Σ
z_1				180	
z_2				165	
z_3				255	
Goal	:	:	:	600	

↳ TT change হলে তার নতুন FF matrix বের করে আবার calc করতে হবে।

Step-2: $\Sigma_{ij}(A_j \times f_{ij})$ → determine

$\Sigma_{11}(A_j \times f_{11}) = 195 \times 0.1 + 165 \times 1.43 + 240 \times 1.4$

$= 598.65$

$\Sigma_{21}(A_j \times f_{21}) = 195 \times 1.43 + 165 \times 1.51 + 240 \times 1.43$

$=$

Lecture – 09 :

05.09.24

Mode choice :

- কী ধরনের transport কী পরিমাণে use হচ্ছে তা বিবেচনা হবে।

- 40% of the total traffic is done by walking & bicycling in BD.

factors affecting mode choice :

1. Availability of Mode
2. Trip purpose → Recreational → Rickshaw/Bicycle/Walk
   → Office → Car
3. LOS – level of service
   → TT → IVTT, OVTT, Waiting time
   → travel time
   → Trip cost
   → Route attributes

OVTT → Out of vehicle travel time
(main vehicle যাওয়ার আগে বা vehicle use করার পরে যে time)

IVTT → In vehicle travel time (destination-এ main vehicle-এ যতক্ষণ time travel করি)

* DOHS to farmgate →
  (i) DOHS to Metrostation → OVTT
  (ii) Waiting for Metro → Waiting time
  (iii) Metro to farmgate → IVTT

4. Traveler characteristics → income

5. Area " → density

density বেশি হলে facilities বেশি থাকে walking preferable হবে বেশি

Estimation of mode choices:

(I) Heuristics → based on trip distances & travel times.

- walking for all trips < 0.5 miles
- driving " " " > 3 miles

(II) fixed percentage → based on existing mode shares

example → 40% (Walking + bicycle)
30% (Car)
30% (public transport/Others)

Suppose, 600 passengers আছে

then walking = 600 × 40%
= 240

(III) Combination → based on existing mode shares for trips of varying distance/

- for trips < 0.5 miles → 75% walking, 10% bike, 0% transit, 15% auto

Mode choice Model :

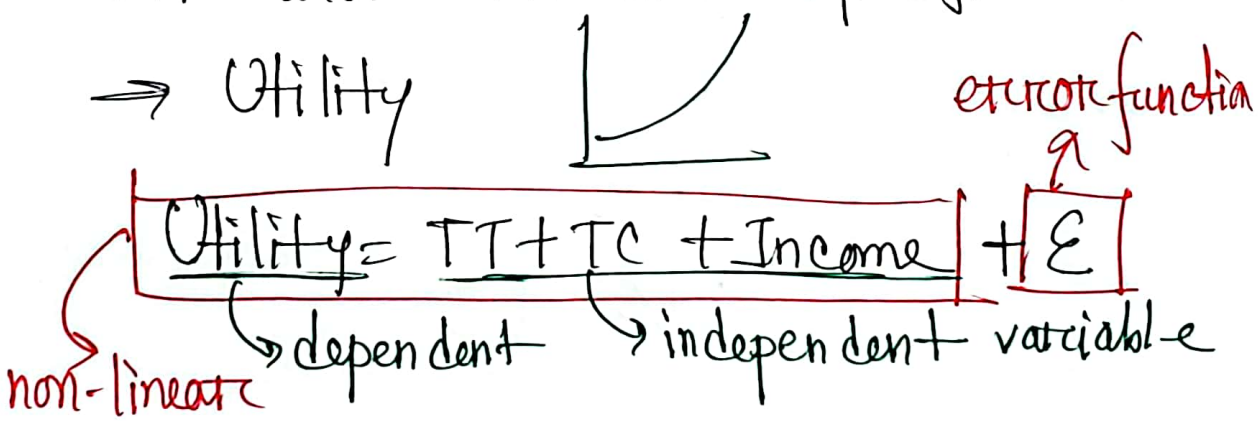
(1) Probabilistic → কোন mode use করবে তার probability বের করা

Opposite

→ Deterministic → 100% sure যে কোনো একটা mode use করবে।

- Non-linear regression on independent variables → LOS, TC (travel Characteristics), AC (area characteristics)

- Dependent variable is not mode choice but unobserved mode-specific variable → Utility



- error function use করা হয় কারণ সব independent variable use করা হয়না/ use variables - এ wrong বা missing data থাকতে পারে। এই eqn সঠিক করার জন্য এটা use করা হয়।

MNL MLC → deterministic

Utility maximization : (formula দিয়ে দিবে)

Example →

Alternative	Time	Cost
Bus	15 min	$2
Car	5 min	$5

Utility function → $U_k = (-0.2) \times time_k + (-1) \times cost_k$

(weightage factor)

যার utility বেশি তা choose করবে।

(a) Which function will be chosen?

$$U_B = (-0.2) \times 15 + (-1) \times 2 = -5$$

$$U_C = (-0.2) \times 5 + (-1) \times 5 = -6$$

$U_B > U_C \rightarrow$ choose Bus

- Utility is inversely proportional to time.
- recreation এর ক্ষেত্রে যত সময় বাড়বে তত trip উপভোগ করবে utility বাড়বে। তখন utility is proportional to time হয়।

12.09.23

Lecture-10:

Example →

Alternative	Time	Cost	Benefit
Car to shop	5 min	$5	Yes
Bus to shop	15 "	$2	Yes
Stay at home	0 "	$0	No

Utility function → $U_k = (-0.5)\text{time}_k + (-1)\times \text{Cost}_k + (20)\times \text{benefit}_k$

Which alternative will be chosen?

$U_{Car} = (-0.5)\times 5 + (-1)\times 5 + (20)\times 1 = 12.5$

$U_{Bus} = (-0.5)\times 15 + (-1)\times 2 + (20)\times 1 = 10.5$

$U_{home} = (-0.5)\times 0 + (-1)\times 0 + (20)\times 0 = 0$

$U_{Car} > U_{Bus} > U_{home}$ → Use Car.

Random Utility Maximization (RUM):

- Source of randomness →

(i) Unobserved attributes
- may not be able to measure all of the attributes considered

(ii) Measurement errors
-

- Answer is probabilistic, not deterministic
- Split utility eqn into measured and unmeasured elements,

$$U_k = V_k + \varepsilon_k$$

V_k → measured utility

ε_k → random error

(i) Deterministic / systematic / observable / measurable utility

Multinomial logic (MNL) Model:

- দুটো veh এর মধ্যে probability বের করবো।

$$P_n(K|C_n) = P_{kn} = \exp(V_k) \div \sum_{l \text{ in } C_n} \exp(V_l)$$

- for 2 alternatives,

(i) $P_{1n} = \exp(V_1) \div [\exp(V_1) + \exp(V_2)]$

(ii) $P_{2n} = \exp(V_2) \div [\exp(V_1) + \exp(V_2)]$

- for 3 alternatives,

(i) $P_{1n} = \exp(V_1) \div [\exp(V_1) + \exp(V_2) + \exp(V_3)]$

(ii) $P_{2n} = \exp(V_2) \div [\exp(V_1) + \exp(V_2) + \exp(V_3)]$

(iii) $P_{3n} = \exp(V_3) \div [\exp(V_1) + \exp(V_2) + \exp(V_3)]$

Example :

Alternative	Time	Cost
Car	5 min	$5
Bus	15 min	$2

RUM-এ V_k measured utility

$V_k = (-0.2)\text{time}_k + (-1)\text{cost}_k$

- Probabilities of choosing each alternative,

$V_{car} = (-0.2)\times 5 + (-1)\times 5 = -6$

$V_{Bus} = (-0.2)\times 15 + (-1)\times 2 = -5$

$\exp(V_{car}) = e^{-6} = 0.00248$

$\exp(V_{Bus}) = e^{-5} = 0.00674$

$\text{Prob}(car) = 0.00248 \div (0.00248 + 0.00674)$

$= 0.269$

$\text{Prob}(bus) = 0.00674 \div (0.00248 + 0.00674)$

$= 0.731$

2 utility sum 1 হতে হবে

Example :

Alternative	Time	Cost
Car	5 min	$5
Bus 1 (blue)	15 "	$2
Bus 2 (red)	15 "	$2

এটি তিনটি alternative থাকলে MNL use করা যাবে কিন্তু bus ২টি একসাথে ২টি থাকলে alternative হবে ২টি, তখন ২টি alternative এরজন্য MNL-এ prob বের করে bus এর টাকে ২ভাগ করে দিতে হবে আর car এর টি আগের মতোই থাকবে।

$$V_K = (-0.2)\,time_K + (-1)\,cost_K$$

- Probabilities of chosing each alternatives,

$$V_{car} = -6, \quad V_{bus1} = -5, \quad V_{bus2} = -5$$

$$\exp(V_{car}) = 0.00248 = e^{-6}$$

$$\exp(V_{bus1}) = 0.00674 = e^{-5}$$

$$\exp(V_{bus2}) = 0.00674 = e^{-5}$$

$$\text{sum} = 0.01595$$

$$\text{Prob}(car) = 0.00248 \div 0.01595 = 0.155$$

$$\text{Prob}(bus1) = 0.00674 \div 0.01595 = 0.422$$

$$\text{Prob}(bus2) = 0.422$$

→ Bus ২টিকে একটা ধরলে ২টি alternative ধরে mat করলে Prob(Car) = 0.269 এবং Prob(Bus) = 0.731 পাই। যেহেতু Bus ২টা তাই

Prob(Bus 1) = Prob(Bus 2) = $\frac{0.7}{2}$ = 0.3655

2টা একদম bus 1, bus 2 এর property same.

Independence from irrelevant alternatives (IIA):

Exp-1 : car and bus alternatives

- 27% car, 73% Bus

Exp-2 : car and two (nearly identical) bus alternatives

- Red/blue bus paradox
- 16% car, 84% bus (total)

Exp-3 : bus and two (nearly identical) car alternatives

- Uber/Lyft paradox
- 42% car (total), 58% bus

XIII-এ আসতে পারে

Explain IIA with another example.

Lecture-11 :

19.09.24

Mode Choice

- Modal split (%)
- Modal shift analysis → gives priority to users

example: travelling time একটা নির্দিষ্ট distance-এ bus এর জন্য কমলে/বাড়লে কোন user রা bus-এ shift করবে।

Mode choice :

Methods →

(i) Utility maximization (U)

(ii) Random Utility maximization (V) → Random error added, probability based

difference between these two

V.V.I

MNL — Multi-Nomial Logit Model

→ error, $\epsilon = 0$

IIA → Independence from irrelevant alternatives

→ describe & give an example V.V.I

Nested logit Model : (IV)

IV → কোনো একটা veh এর ২টা ভাগ দেখাতে হলে ঐই variable এ veh এর জন্য use করবো

m = nesting parameter → (0-1)

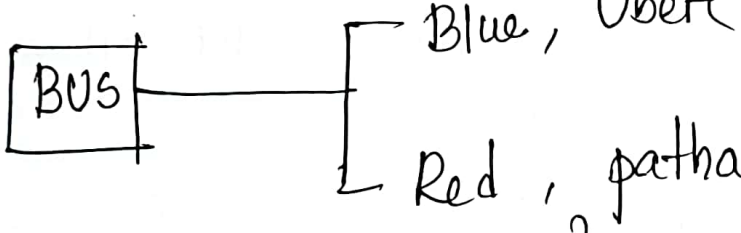
m=0 → যখন এটা veh এর মধ্যে ভাগ থাকলেও preference এর ক্ষেত্রে কোনো matter করবেনা

(Example → blue bus, Red bus } যেকোনো একটা select করলেই হবে)

m=1 → যখন এটা veh এর মধ্যে ভাগ থাকলে choice এর ক্ষেত্রে matter করবে. (Example → Car (Uber), Car (pathao)

↙ Choice করার ক্ষেত্রে ভাবতে হবে)

IV → inclusive utility



→ একই nest -এ দুটো ভাগ আছে এরা dependent

এক অপরের উপর : V_{bus} → IV_{blue}

IV_{Red}

- Conditional probabilities (within each nest)

Example : m এর value বলে দিবে.

Alternative	Time	cost
Car	5 min	$5
Bus 1 (blue)	15 min	$2
Bus 2 (red)	15 min	$2

Correlation → how much they are related to each other

$V_K = (-0.2)\,time_K + (-1) \times cost_K$

Buses 1 & 2 in nest with $m = 0.15$

(correlation = 0.85) → correlation বের করার m এর value তে করা।

↳ (1−m)

two parts in 1 nest → IV নির্ণয় করতে

Soln:

Probabilities of choosing each alternatives,

$$IV_{bus} = m_{bus} \times \ln\left[\exp\left(V_{bus1} \div m_{bus}\right) + \exp\left(V_{bus2} \div m_{bus}\right)\right]$$

$$= 0.15 \times \ln\left[\exp\left(-5 \div 0.15\right) + \exp\left(-5 \div 0.15\right)\right]$$

$$= 0.15 \times \ln\left[3.34E\text{-}15 + 3.34E\text{-}15\right]$$

$$= 0.15 \times -32.64 = -4.896$$

$$\text{Prob(car)} = \exp(V_{car}) \div [\exp(V_{car}) + \exp(IV_{bus})]$$

$$= 0.00248 \div [0.00248 + 0.00748]$$

$$= 0.00248 \div 0.00996 = 0.249$$

$$\text{Prob(buses)} = \exp(IV_{bus}) \div [\exp(V_{car}) + \exp(IV_{bus})]$$

$$= 0.751$$

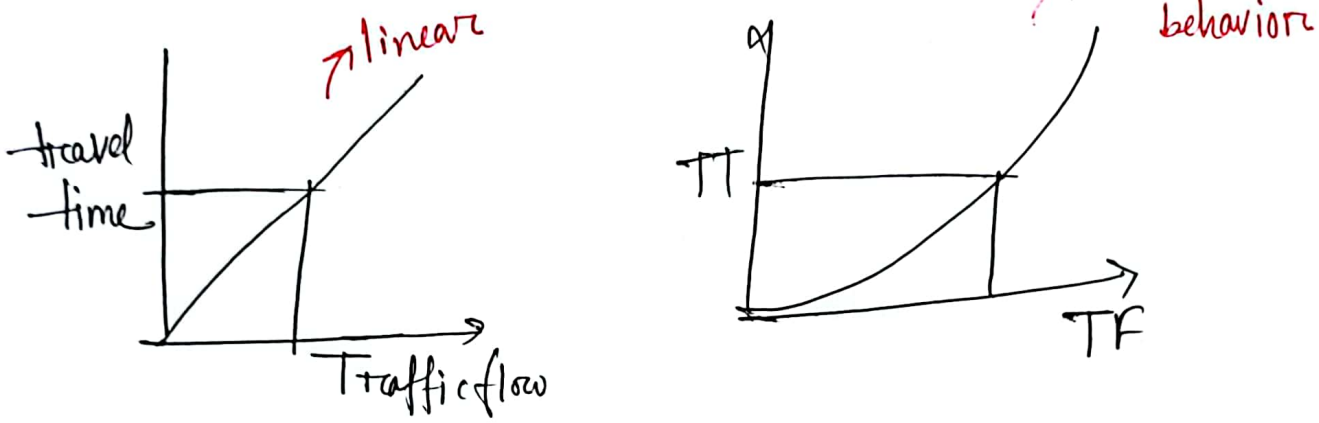
Policy analysis application : কীভাবে bus mode কে বেশি popular করা যায় car এর তুলনায়

→ এটাকে mode shift analysis বলে।

02.10.24

Lecture-12:

AON → uncongested অবস্থায় কি পথে travel time কম হয় সে পথে যাবে।



Congested condition:

Bureau of Public Roads (BPR):

$$t = t_0\left[1 + \alpha\left(\frac{V}{Q}\right)^{\beta}\right]$$

V.V. ↑

- t → traffic flow
- t_0 → free flow travel time (non-congested)
- V → traffic Volume
- Q → Capacity

$\alpha = 0.15$; $\beta = 4$

User equilibrium (UE) assignment:

- Wardrop's defn → The travel time between a specified origin and destination on all used routes is equal and less than or equal to the travel time that would be experienced

- ততক্ষণ পর্যন্ত কারণ travel time মুক্ত রাখা use করবে যতক্ষণ না তারা congested হবে,

path costs → travel time

first principle : (UE) → drivers self-fish behave করবে.

Second principle : (System equilibrium / optimal)

- সবার জন্য ভালো

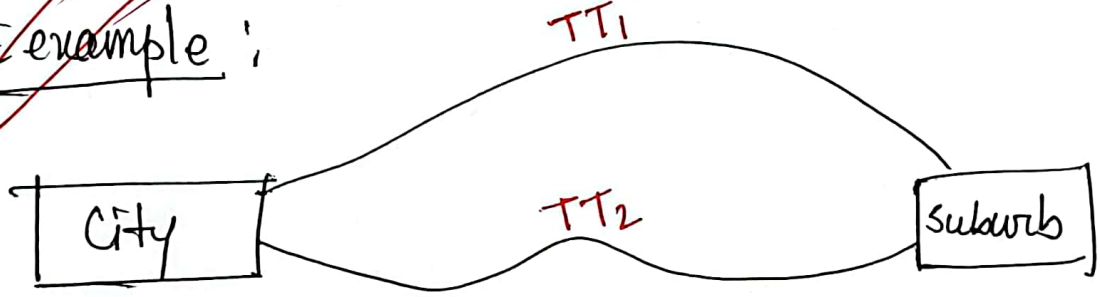
. Current situation of BD → User equilibrium

Congestion pricing

CAV → Connected Autonomous Vehicle

V.V.I

UE example :



- During peak-hour morning commute, a total of 4500 vehicles travel from the suburb to the city
- The travel time functions for these routes are given,

$TT_1(x_1) = 6 + 4x_1$

$TT_2(x_2) = 4 + (x_2)^2$

Where $TT(x)$ is travel time in min x is traffic volume 1000.

Step-1: Write eqn,

$TT_1(x_1) = 6 + 4x_1$

$TT(x_2) = 4 + (x_2)^2$

flow constraint $\Rightarrow x_1 + x_2 = 4.5$ → 4500 in thousands

Step-2: Check if both routes will be used

(i) All or nothing assignment on route 1 ($x_1 = 4.5$, $x_2 = 0$)

$TT_1(4.5) = 6 + 4 \times 4.5 = 24$ min

if $x = 0.1$ for 100 veh.

$TT_2(4.5) = 4 + (0)^2 = 4$ min

$TT_2 < TT_1$

If all the traffic is on route 1 then route 2 is the desirable choice.

$TT_1 = 6.4$

$TT_2 = 4$ $TT_2 < TT_1$

(ii) All or nothing assignment on Route 2 ($x_1 = 0$, $x_2 = 4.5$)

$TT_1 = 6$ $TT_2 < TT_1$

$TT_2 = 4.01$ $TT_1(4.5) = 6 + 4 \times 0 = 6$ min

$TT_2 > TT_1$

only route 2 will use $TT_2(4.5) = 4 + (4.5)^2 = 24.25$ min

Therefore, both routes will be used

for 100 veh, $x_1 = 0.1$

for route-1,

$TT_1 = 6.4$ min
$TT_2 = 4$ min
$\Big\}\ TT_2 < TT_1$

for route-2,

$TT_1 = 6$ min
$TT_2 = 4.01$ min
$\Big\}\ TT_2 < TT_1$

⇒ দুই ক্ষেত্রেই যদি আলাদা আলাদা রাস্তায় সব গাড়ি চলে অন্য রাস্তায় না চলে তবে route 2 এর সময় দুইক্ষেত্রেই কম। তাই এক্ষেত্রে route 2 bes-

Step-3 :

- Equate travel times and solve
  - Apply Wardrop's 1st principle requirements
  - All routes used will have qual time, and ≤ those on unused routes.
  - Hence, if flows are distributed between route 1 and Route 2

At use quilibriums

Other traffic assignment method আছে।

Solve for x_1 and x_2,

$$x_1 + x_2 = 4.5 \rightarrow x_2 = 4.5 - x_1$$

$$\Rightarrow 6 + 4x_1 = 9 + (x_2)^2 \rightarrow 6 + 4x_1$$

V.V.I

(x) Are these principles compatible? Does the first lead to the second?

⇒ No, they are not compatible. They deliver two different meanings.

Strategy → (1) Congestion pricing → toll plaza

Braess' paradox → xm-2 নাই