Ahad Sir

08.05.24

Lecture-01:

Household travel survey:

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

(1) Trip generation → full slide
(2) Trip distribution → page (1-37)
(3) Mode choice → page (1-32)
(4) traffic assignment → (page-(1-35)

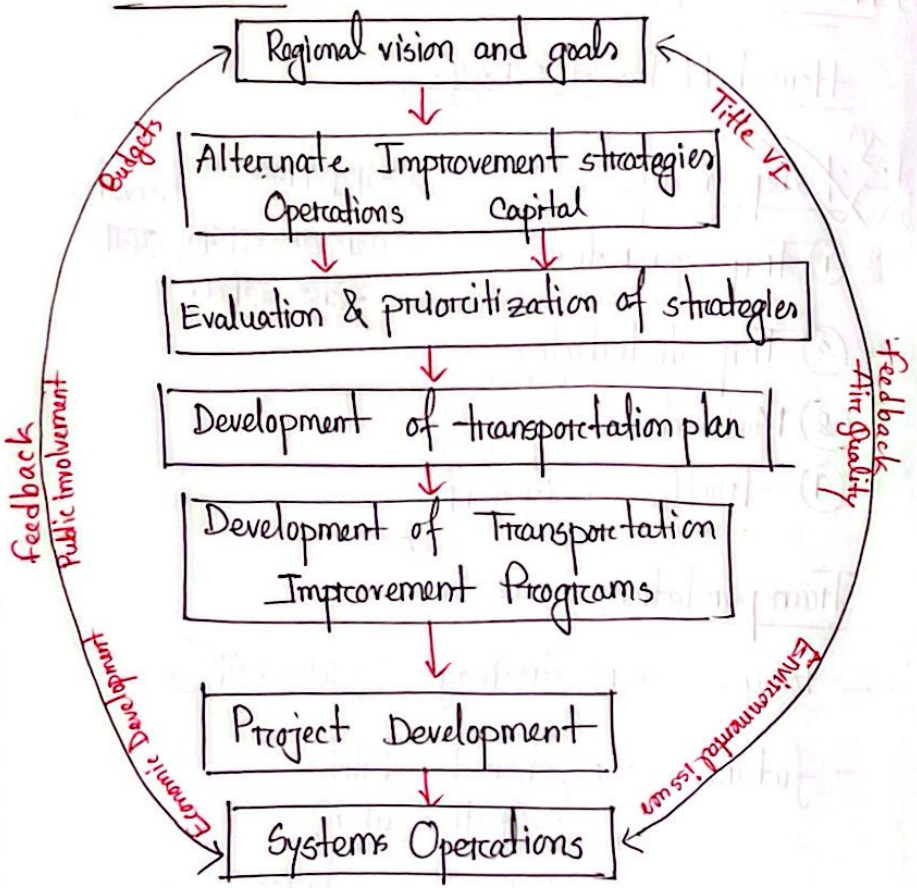
Transportation issue:

- 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 এরকম thesis paper পাবা তা দেখতে হবে, RSTP-A-Comptehensive-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 কতটুকু পাবে 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 (Dohs)	Zone #2 (Kalc
① household size →	(4) Unit 1	(5+) Unit 2
② household income (monthly) →	1 lac	30000
③ Vehicle ownership →	1+	0

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Tb → Urban map

④ Political boundary
↳ কলকাতা ward/
মিলে TAZ হয়
পারে

- inter zonal trip → minimized হবে এমন
উপর zone select করতে

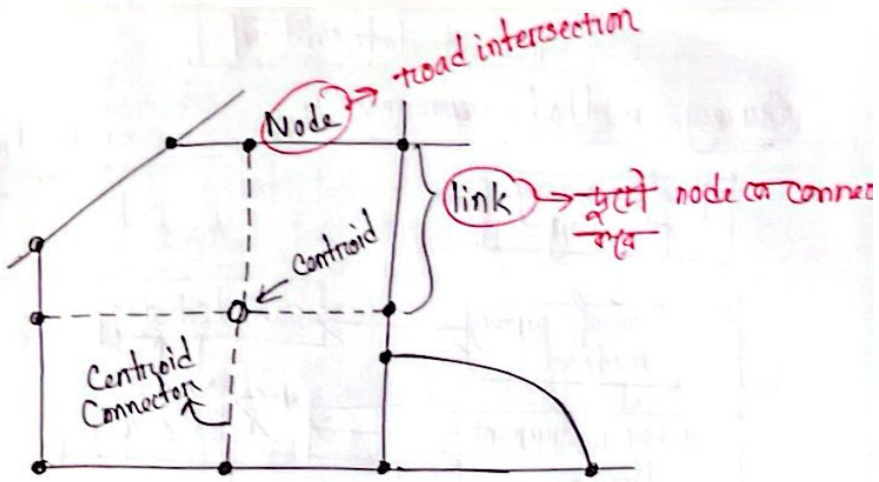
- CBD area → Central Business District

Criteria used to define TAZ:

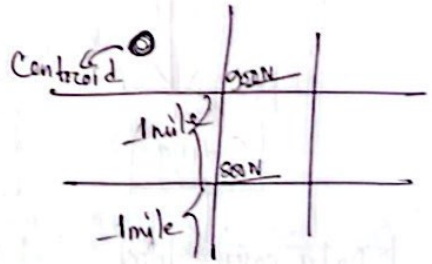
- homogeneous socioeconomic characteristics
for zone's population.
- Basing zonal boundaries on census zone.

Transportation network:

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



- 1 mile এর block এলাকা যার ভিতরে residential/
Commercial area থাকবে, সেটা centroid থাকবে



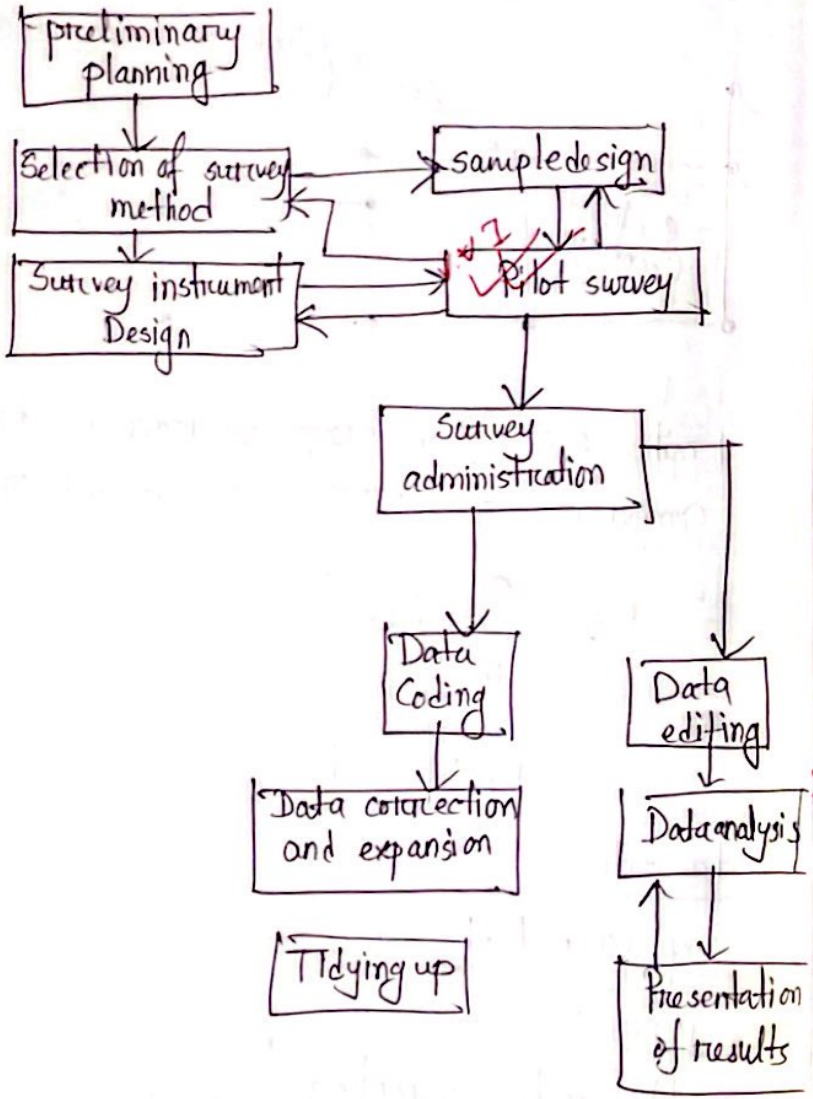
Data collection:

Sampling method →

Types:
① Random sampling
② Stratified sampling → কিছু নির্দিষ্ট অনুসারে
তাকে sample data
নিল
③ Convenience "

transit data impact

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 numbers of miles of routes by type and company.
- Route number, description and terminal to terminal mileage.

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Traveler characteristics:

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

Household travel survey:

- Format of the survey → Home interview
  - → Phone "
  - → Mail back survey
- Temporal dimension "
  - → Cross-sectional (random stratified survey) (১০ বছর পরপর)
  - → Panel survey (একই group of people কে selection করে বছর বছর data collect করা।)

⊛ Revealed preference survey:

(structure existing)

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

Stated preference survey: (SP survey)

(structure existing)

- 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 → level.

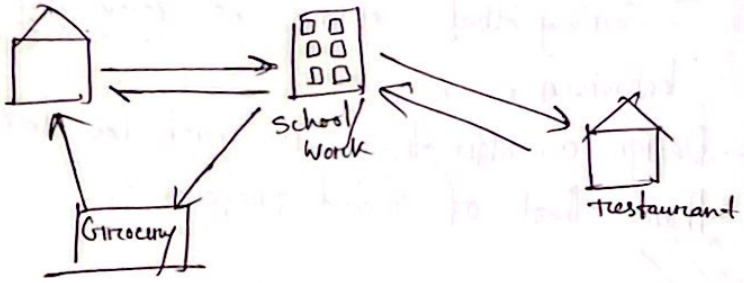
Option-2: Personal car

TT, 10 min → levels

TC, 100 tk → levels

(TT, TC = attributes)

Revealed Preference survey:



- Attitudinal survey example
- pedestrian survey → ২৭১৫ ২৭৪ . (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)

linear → slope same
non-linear → slop same না

TAZ → Traffic Analysis Zone

V.V.I

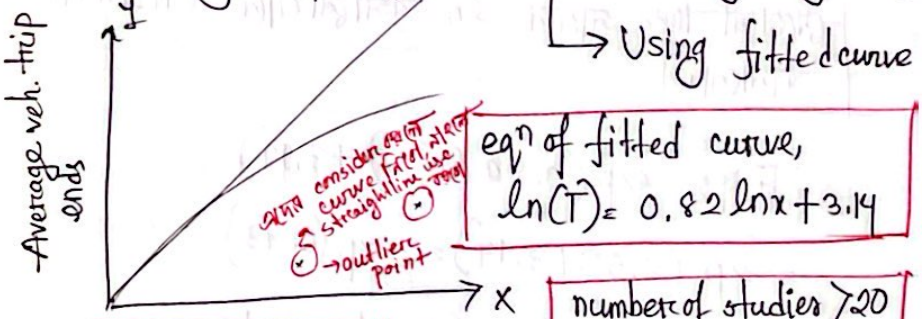
Example:

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

for HW

– 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 × (200' × 100'/story)
= 4 × 200 × 100 = 80000 sq. ft

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

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

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Method-2 ; Equation

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

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

এলোমেলো ডিটার সামনে ln বসানোমানে straightline 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

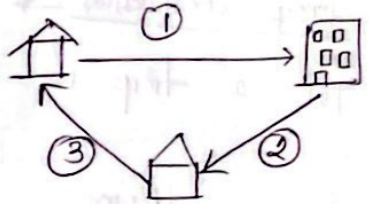
- We should select 840 between 840 and 649 because higher trips are safer for design.

Trip generation – data collection :

- 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-homebased restaurant trip (NHR)
3. Home based

Trip যতগুলো কোরে home থাকলে home based বলা।

Lecture – 05 : 27.06.24

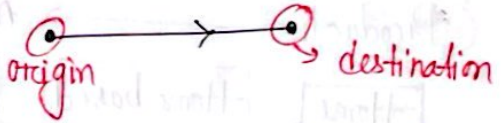
Supplementary Document-2 এর অংশ

Trip generation : যেভাবে ভাগ করা যায় →

(i) Individual site – একটি পরিমাণ trip generate হয়

(ii) zonal level (TAZ)

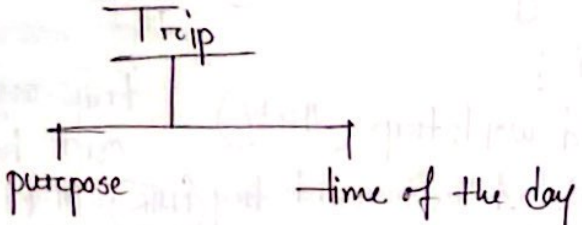
Definition :



(i) Trip end → the two end points of a trip

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

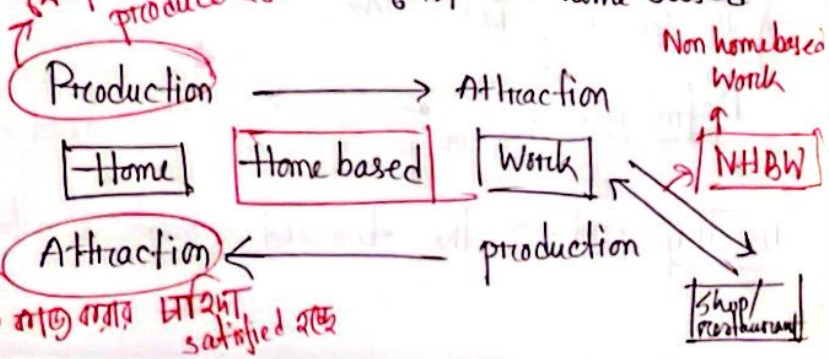
③ Trip attraction → Where the need/desire for a trip is satisfied.

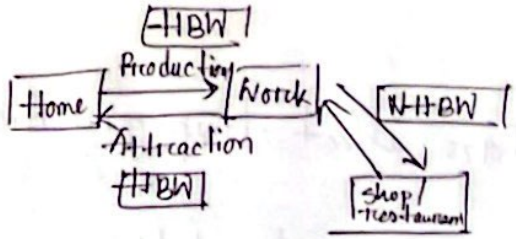


PA → Production & Attractions
OD → Origin & Destination

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+ attribut
  - 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.

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(

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 হচ্ছে।

TAZ 123 has →

50 HHs with 0 workers

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

Trip attractions: → x-n-2 linear eqn develop করে দিবেনা। eqn দিবেদিবে

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 + 2 ans আসে

Previous year Ques

(X) What factors affect trip generation rates?

(X) Are trips rates stable? Across time? Between regions?

(X) What would happen to trip generation rates with → @ Rise in e-commerce

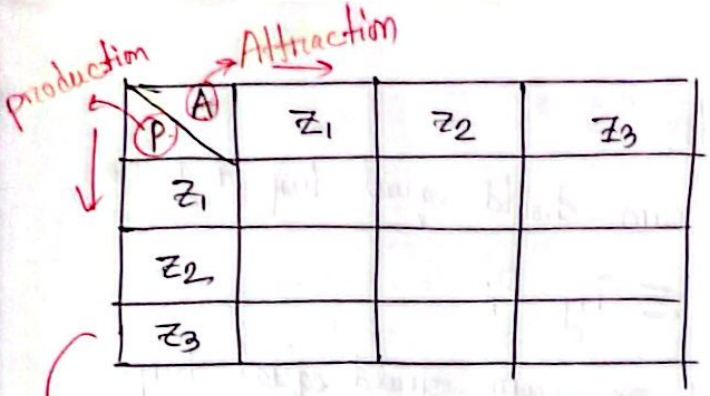
(b) Drone-based deliveries?
(c) New out-of-home activities?
(d) Autonomous vehicles?
(e) Virtual reality in the home?

VTT → Value of Travel Time
→ VTT বাড়ছে autonomous veh বাড়ছে.

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 হচ্ছে।

- matrix ২ রকম →
(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. i_1 = production zone 1
7. j_1 = attraction zone 1
8. T = Trip ; 9. TT = Travel Time

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Constraints:

(i) Row sum should equal trip productions

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

(ii) Column sum should equal trip attractions

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

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 considere when you choose a destination?

⇒ বাধা → যেখানে যাবা যেখানে service কেমন

- Impedance / LOS →
  - Travel time or (generalized) cost
- Attractiveness → কোনো উপজেলায় যাওয়ার সুবিধা কী?
  - #trip attractions
  - Employment by type

Trip distribution methods: (3 models)

(1) Growth factore model → Fratar / Furness metho.
→ Iterative fitting of growth factors

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

(3) Destination choice model → disaggregate approac
→ Multinomial logit model

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Growth factor model:

Simple:

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

Base year

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

Forecast year

$$T_{ij} = r \times T_{ij}$$

T_{ij} → forecast trip; r → growth factor; T_{ij} → base year trip

(*) Base year matrix ভিত্তিক always

Singly constrained:

- forecast year এর একটা goal দিলে কিছু zone-এ কত trip generate হবে তা হিসাব করতে হবে।
- first-এ growth factor বের করতে হবে, then base year এর সাথে গুণ করে forecast year বের করতে

Base year

P \ A	Z_1	Z_2	Z_3	Total	r_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				

Growth factor

$r_1 = \frac{180}{150} = 1.2$

$r_2 = \frac{165}{150} = 1.1$

Trip বড় হলে, তাতাতাড়ি ভাগ করা যায়

Doubly constrained:

- Base year এবং forecast year এর জন্য Iterative method use করতে হয়।
- কারণ base year এবং forecast year দুটোতেই goal দিয়ে দিবে।

Base year

P \ A	z_1	z_2	z_3	Total	Goal	T_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 T_i বের করে iteration (1) করবে then changed attraction থেকে attraction end-এ Growth factor বের করে iteration (2) করবে তারপর production end change হবে, তখন আবার production end-এ Growth rate বের করে আবার iteration (3) করবে।

- দুই পাশের Growth factor 1 এর কাছাকাছি আসলে iteration stop করবে।

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

- 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	
Goal	195	165	240	

forecast year (2)

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 traveling time এবং cost দুটোই বাড়বে

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

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

friction factor :

(i) parametric → mathematical relation follow করে
(ii) Non parametric

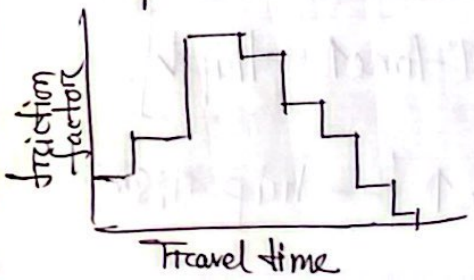
parametric (mathematical eqn) →

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

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

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

Non parametric (look-up table) →



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

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friction factor এর congestion হিসেবে ধরলাম বাস্তবে

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 impedence) matrix

trip production change হলে আবার আলাদা করে

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-এ 100 trip attracted

z_1 থেকে z_1-এ 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

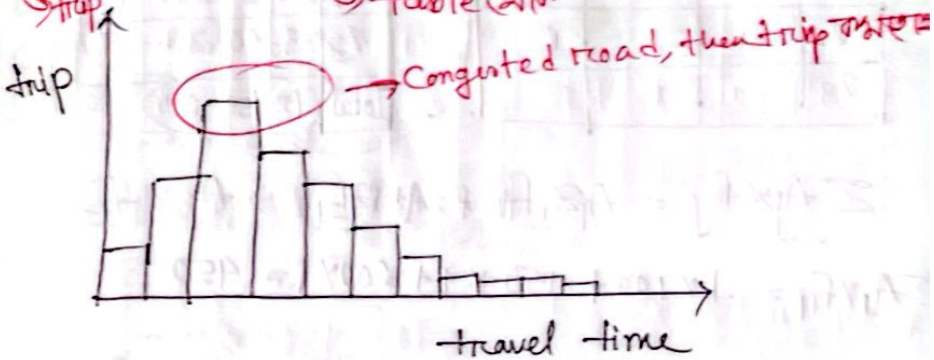
② Travel time↑ trip↓

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 factor develop করা।

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

P, A

Set up:

step ①: Determine friction factor

- Assume initially $f_{ij} = 1$
- Create f_{ij} matrix
- Calculate denominator form

$\Sigma_{ij} (A_j \times f_{ij})$ ← Sum product

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, $ffnew = ffold \times \left(\frac{Obs}{Est}\right)$
- Repeat steps ① to ⑤ until ffs don't change.

— Travel time এর range-1 ভাঙা করতে হবে। (2nd range same assumption এর জন্য 2nd master)

Ques-2 এর (base year এর) assumption অনুযায়ী

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+95+100+95 = 290	1.95

2 ঘন্টার range এর জন্য 0.1

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

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

TT (1-10)-1 estimated trip = $T_{11} + T_{22} + T_{33}$ (TT⑤ TT④ TT③)

$= 33.3 + 50 + 66.7$

$= 150$

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

$= 33.3 + 66.7$

$= 100$

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

$= 200$ $66.7 + 50$

$ff_{new} = \frac{\text{Observed}}{\text{estimated}} \times ff_{old}$

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

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	3825
Total	108.1	153.3	188.6	450	

Base year ① এর 100, 150, 200 use করবে।

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

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

$= 517.45$

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

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

$= 450$

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

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

$= 382.5$

Base year ① এর value use করবে

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

$= (150 \times 100 \times 0.1) \div 517.5$ (new)

$= 2.9$

Base year ② → Base year ① এর data use করে করবে।

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

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

$= 84.1$

- দুই decimal পর্যন্ত মানে / এক decimal
- যতক্ষণ না পর্যন্ত $|ff_{new} - ff_{old}| < 0.01$ or 0.001 হবে ততক্ষণ পর্যন্ত trial দিতে হবে।
- marks বেশি থাকলে trial বেশি। trial কম হলে question বলে দিবে কত base year পর্যন্ত মানে। Suppose, base year ② পর্যন্ত মেতে বলবে।

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16.07.24

Lecture-08:

base year এর data লাগবে।

Gravity model application : (doubly constrained)

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

forecast year

P/A	z_1	z_2	z_3	Goal
z_1				180
z_2				165
z_3				255
Goal	195	165	240	600

এরা দেয়া থাকবে

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 তৈরি 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	

ATT change হলে নতুন FF matrix তৈরি করে আবার calc করতে হবে।

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

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

$= 598.65$

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

=

05.09.24

Lecture – 09:

Mode choice:

- কী ধরনের transport কী পরিমাণে use হচ্ছে তা বিবেচনা করা।
- 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
   (i) DOHS to farmgate →
   (i) DOHS to Metrostation → OVTT
   (ii) Waiting for Metro → Waiting time
   (iii) Metro to farmgate → IVTT

OVTT → Out of vehicle travel time

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

4. Traveler characteristics → income
5. Area → density

density বেশি হলে facilities বেশি থাকে walking preferable হওয়ার জন্য

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/duration.

- 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 হয়ে 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



$$\text{Utility} = TT + TC + \text{Income} + \varepsilon$$

ε → error function

Utility → dependent; TT, TC, Income → independent variable; non-linear

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

Utility maximization: (mode অনুযায়ী) → deterministic (formula দিয়ে দিবে)

Example →

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

Utility function → $U_k = (-0.2) \times \text{time}_k + (-1) \times \text{cost}_k$

((-0.2) = weightage factor)

(যার utility বেশি তাকে 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 অপেক্ষা করে utility বাড়বে। তখন utility is proportional to time হয়।

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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,

$U_k = V_k + \varepsilon_k$ → random error

V_k → measured utility

(1) Deterministic / systematic / observable / measurable utility

$V_k = \sum_m$

Multinomial logic (MNL) Model:

- দুটো veh এর মধ্যে probability বের করবো.

$$P_n(K|C_n) = P_{Kn} = \exp(V_K) \div \sum_{\ell \text{ in } C_n} \exp(V_\ell)$$

- 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,

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

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

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

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

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

$= 0.269$

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

$= 0.731$

দুটোর sum 1 হচ্ছে

Example:

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

এই তিনটি alternative থেকে MNL use করা যাবে কিন্তু bus দুটি একই রকম বলে alternative হবে ২টি, এবং ২টি alternative থাকলে MNL-এ prob বের করার জন্য bus এর টিকে রেখে একটি বাদ দিতে হবে তাই car এর টি আগের মতোই থাকবে।

$V_K = (-0.2)\text{time}_K + (-1)\text{cost}_K$

- Probabilities of choosing each alternatives

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

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

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

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

Sum $= 0.01595$

Prob (car) $= 0.00248 \div 0.01595 = 0.155$

Prob (bus 1) $= 0.00674 \div 0.01595 = 0.422$

Prob (bus 2) $= 0.422$

→ Bus দুটিকে একটা করলে ২টি alternative ধরে math করলে Prob(car) = 0.269 এবং Prob(Bus) = 0.731 পাই। যেহেতু Bus ২টি তাই

Prob(Bus 1) = Prob(Bus 2) $= \frac{0.731}{2} = 0.3655$

২টি যেহেতু 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

xxx-এ আসতে পারে

(x) Explain IIA with another example.

10.09.24

Lecture-11:

Mode Choice

- Modal split (%)
- Modal shift analysis → gives priority to users
  - example: travelling time একটা নির্দিষ্ট distance-এ bus এর জন্য কমবেশি কারণে car 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

MNL — Multi-Nomial Logit Model

error, $\epsilon = 0$

IIA → Independence from irrelevant alternatives

describe & give an example

Nested logit Model: (IV)

IV → কোনো একটা veh এর বেশি ভাগ দেয়া থাকলে সেই variable এ veh এর জন্য use করবো

m = nesting parameter → (0-1)

m=0 → যখন বেশি veh এর মধ্যে ভাগ থাকলেও preference এর ক্ষেত্রে কোনো matter করেনা

(Example → blue bus, Red bus } কোনোটা বেশি select হবে)

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

IV → inclusive utility

BUS → Blue, Uber / Red, pathao

একই nest-এ দুটো ভাগ তাই এরা dependent

এদের উপর : $V_{bus} \rightarrow IV_{blue}$, 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

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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 যত বেশি m এর value তত কম.

↳ $(1-m)$

two parts in 1 nest → IV নিয়মতেরে

Soln:

Probabilities of choosing each alternative,

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

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

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

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

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

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

$$= 0.00248 \div 0.00996 = 0.249$$

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

$$= 0.751$$

Policy analysis application: কীভাবে bus mode কে কিভাবে popular করা যায় বা কোন কোন আইডিয়া

↳ এভাবে mode shift analysis করে.

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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 যত বেশি m এর value তত কম।
↳ (1−m)

two parts in 1 nest → IV নিয়মতহবে

Soln:

Probabilities of choosing each alternatives,

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

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

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

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

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

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

$$= 0.00248 \div 0.00996 = 0.249$$

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

$$= 0.751$$

Policy analysis application: কীভাবে bus mode কে কেমন popular করা যায় বো এর আলোকে
↳ এভাবে mode shift analysis করে।

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Lecture-12:

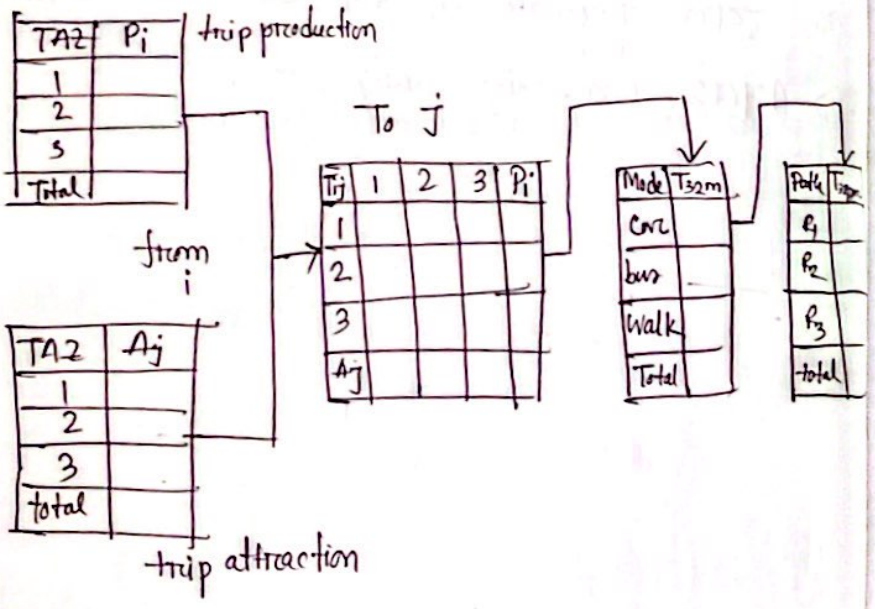
26.09.24

Traffic assignment (or route choice):

↳ Only congested and uncongested conditions (AON and UE) are included in syllabus

Trip Generation → P_i, A_j | Trip distribution → T_{ij} | Mode choice → T_{ijm} | Route choice → T_{ijmr}

Traffic Analysis zone



Outline:

Traffic assignment overview

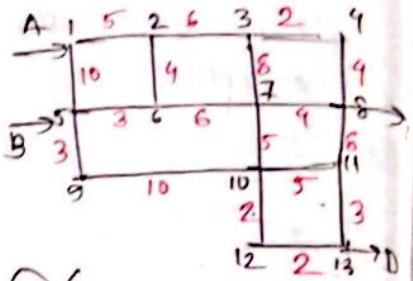
- Uncongested conditions
  - All-or-nothing assignment
  - example
- Congested conditions
  - User equilibrium
  - example

AON example : → link flow কত হবে তাই

- OD matrix (Origin-destination) → demand

Origin \ destination	A	B	C	D
A	0	0	400	200
B	0	0	300	100
C	0	0	0	0
D	0	0	0	0

Travel times



Step-1 : Shortest path নির্ণয় করা

A → C = 1-2-3-4-8 → 17 min

A → D = 1-2-6-7-10-12-13 → 24 min

B → C = 5-6-7-8 → 13 min

B → D = 5-9-10-12-13 → 17 min

Step-2 : Assign all demand between a zonal pair to the shortest path between zones.

A-D যে যথন যাবে 1 → 2 zone use করবে

A-C " " " 1 → 2 " " "

তাই 1-2 তে total গাড়ি যাবে = 400 + 200 = 600

- Travel time অথবা কম যাওয়ার use করা হচ্ছে সেই অনুযায়ী flow হবে। (A → C + A → D) = (400+200) = 600

Link	flow	Link	flow
1→2	600	5→6	300
2→3	400	5→9	100
3→4	400	9→10	100
4→8	400	10→11	0
2→6	200	11→13	0
6→7	500	10→12	300
7→8	300	12→13	300
3→7	0	7→10	200
1→5	0	6→11	0

✓ সঠিক ans

→ A → D + B → C
= 200 + 300
= 500

AON summary :

- The Dijkstra's algorithm → determination of the shortest path.

---

1. Mode choice → difficult question আসবে
2. Trip generation → assignment এর অংশ আসবে।

③ Math ছবিটা আসবে

④ Theory গুলো class-এ বলা হয়েছে তেমনগুলো

Syllabus:

① Transportation flow chart

② Trip generation → Assignment (HH)

③ " Distribution → Growth factor model, ~~Gravity~~ model
↳ formula use করা হয়েছে

④ Mode choice
↳ Random utility maximization
↳ হাতে আছে, কোনটা কী mode

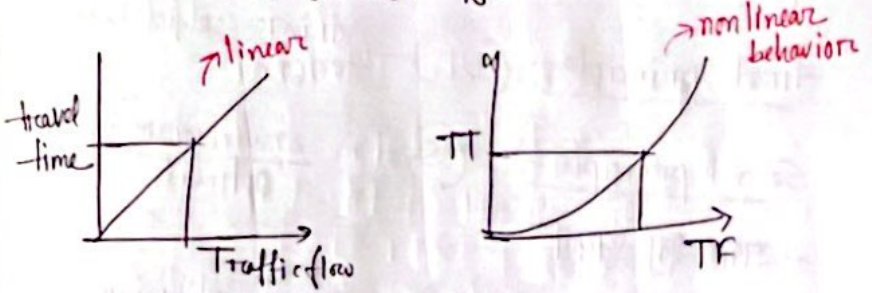
⑤ Traffic assignment
↳ Congested
↳ Uncongested
} math

Game theory

02.10.24

Lecture - 12:

AON → uncongested অবস্থায় যে পথে travel time কম 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 def^n → 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 কারও travel time মুক্ত রাখা use করতে পারবে না যদি congested হবে।

path costs → travel time

- first principle : (UE) → drivers selfish behave করবে।

Second principle : (System equilibrium / optimal)

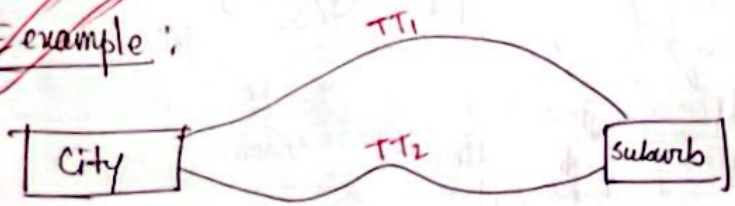
- সবার জন্য ভালো

. Current situation of BD → User equilibrium

Congestion pricing

CAV → Connected Autonomous Vehicle

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 ⇒ $x_1 + x_2 = 4.5$ → 4500 in thousands

Step-2 : Check if both routes will be used

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

যদি 1 no route-1 এ যায় এবং 2 no route-1 এর 25 min এর থেকে time লাগে তাহলে 1 এর 2 যাবে

$TT_1(4.5) = 6 + 4 \times 4.5 = 24$ 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
} $TT_2 < TT_1$

for route-2,

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

⇒ দুইক্ষেত্রেই যদি আলাদা আলাদা রাস্তায় সব গাড়ি চলে অন্য রাস্তায় না চলে তবে route 2 এর সময় দুইক্ষেত্রেই কম। তাই এক্ষেত্রে route 2 best

Step-3:

- Equate travel times and solve.
  - Apply Wardrop's 1st principle requirements
  - All routes used will have equal 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।

Now Solve for x_1 and x_2,

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

$\Rightarrow 6 + 4x_1 = 4 + (x_2)^2 \rightarrow 6 + 4x_1 = 4 + (4.5 - x_1)^2$

V.V.I

(*) 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 না?

Exam

① Trip generation:

Method-1 → avg. rate

Method-2 → equation

avg rate method:

- X = floor area in terms of 1000 sq.ft
- per 1000 sq.ft floor area তে কত trip vehicle end হয় তা দিলে দিবে। → তা trip rate

∴ **Trips = avg.trip rate X x**

equation method:

- exam-এ eqn দিয়ে দিবে

X → floor area per 1000 sq.ft

- eqn-এ x এর value বসালে trips পাবে।
- দুটো method থেকে যেই trip বেশি সেই হবে নিবা।

example

Trip rate = Total homebased trips total / Total household size

Trip ends → koo ends of a trip

Trip production → trip need demanded (trip produce হয় যেখানে)

Trip attraction → trip need satisfied (demand satisfied হয় যেখানে)

HBW production = Trip rate x no of HH having coorkers

Trip attractions = rate x job/HH/social

Trip rate = Total homebased school trips / Total college students

example

Example-01:

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

Method-1:

Total floor area = 4 (no of storey) x (200' x 100' floor area)

= 80000 sq.ft

∴ X = 80000 / 1000 = 80

∴ Trips = avg.rate x x = 8.11 x 80

= 648.8 ~ 649 trips

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method-2 :

$x = 80$

eqn,

$\ln(\text{trips}) = 0.82 \ln(x) + 3.14$

$\Rightarrow \ln(\text{trips}) = 0.82 \ln(80) + 3.14$

$\Rightarrow \text{trips} = \exp(3.50 + 3.14)$

$\Rightarrow \text{trips} = 839.8 \sim 840$

Example-2 :

Trip productions of TAZ123 :→

HBW trip productions :

0 worker : $50 \times 0 = 0$

1 " : $100 \times 1.38 = 138$

2 " : $200 \times 2.39 = 478$

3+ " : $50 \times 3.88 = 194.0$

∴ Total trip production = 0+138+478+194

= 810 HBW

Example-03 → eqn exam-2 দিয়েছিল

Trip attractions of TAZ123 →

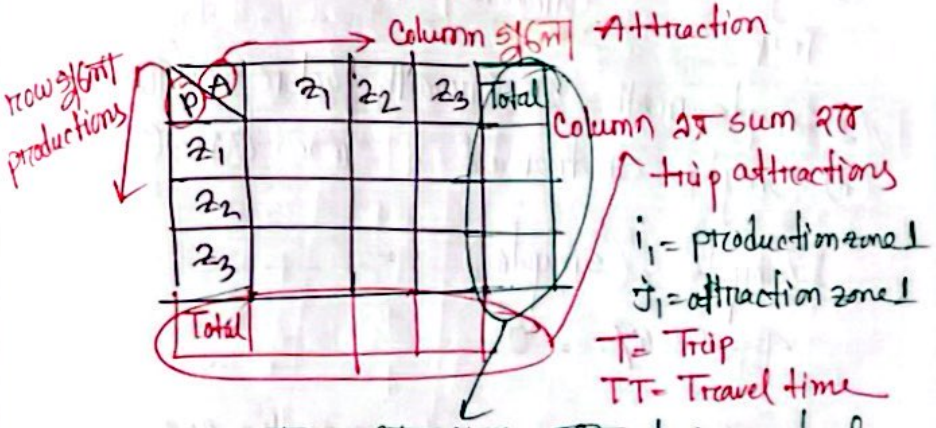
HBW : 1.25 trip/job = 1.25×600 = 750 HBW trip attractions

HBSocial : 0.9 per office job + 0.25 per govt. job + 0.3 / household

$= 0.9 \times 400 + 0.25 \times 200 + 0.3 \times 400$

$= 360 + 50 + 120 = 530$ HBsocial trip attractions.

② Trip distribution : 2 type matrix → ① PA ② OD



i = production zone

j = attraction zone

A_1 = zone 1 এ total attraction

A_2 = zone 2 " " attractim

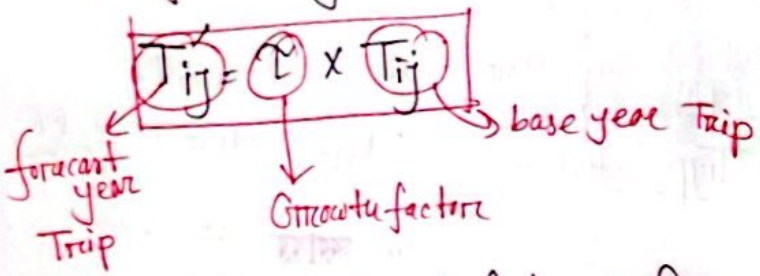
P = zone 1 " " production

Singly constained → কোনো এক fixed (usually production)

doubly constrained → ২টি fixed

Growth factor model :

- base year এর PA/OD matrix দেয়া থাকবে এবং future trip এর কিছু info দেয়া থাকবে,
- Growth factor বের করে base year-এ apply করে future year matrix পাবে



① Simple math-এ Growth factor বলা দিবে
② Singly constrained-এ " " বের করতে হবে

Example : (Simple)

$\tau = 1.2$

Uniform - area-wide growth = 20%.

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

Base year

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

→ Same হবে

forecast year

P/A	z_1	z_2	z_3	Total
z_1	8	60	114	180
z_2	54	6	120	180
z_3	60	114	6	180
Total	120	180	240	540

Singly constrained : $T_{ij}' = \tau \times T_{ij}$

↳ কোনো এক future Goal দিয়ে দিবে এবং Goal fixed

→ τ (P/A) বের করে নিতে হবে ; $\tau_i = \frac{\text{Goal } (P_i)}{\text{Base year Total } (P_i)}$

Example:

Base year

P/A	z_1	z_2	z_3	Total	Goal	τ_i
z_1	5	50	95	150	180	$\frac{180}{150} = 1.2$
z_2	45	5	100	150	165	$\frac{165}{150} = 1.1$
z_3	50	95	5	150	255	$\frac{255}{150} = 1.7$
Total	100	150	200	450	600	—

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	85	161.5	8.5	255
Total	140.5	227	232.5	600

round করতে হবে

কোন্ column এর

সোজাসুজি = 600 ⟹ বিলাইছে ⟹ OK

→ iteration step exam-এ দেয়া দিবে।

Doubly constrained : $T_{ij} = \tau \times T_{ij}$

- ২টি fixed (P/A) future Goal দিয়ে দিবে থাকবে
- ২টি তদনুযায়ী Growth factor বের করতে হবে।

$$\tau_i = \frac{P_i(\text{Goal})}{P_i(\text{Base})} \; ; \; \tau_j = \frac{A_i(\text{Goal})}{A_j(\text{Base})}$$

Example :

Base year

iteration step এভাবে হবে $\left|T_{ij} - |T_{ij-1}\right| < 0.01$ or 0.001

P/A	z_1	z_2	z_3	Total	Goal	τ_i
z_1	5	50	95	150	180	$\frac{180}{150} = 1.2$
z_2	45	5	100	150	165	$\frac{165}{150} = 1.1$
z_3	50	95	5	150	255	$\frac{255}{150} = 1.7$
Total	100	150	200	450		
Goal	195	165	240			
τ_j						

forecast year

P/A	z_1	z_2	z_3	Goal
z_1				180
z_2				165
z_3				255
Goal	195	165	240	600

Solⁿ :

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	600
Goal	195	165	240	
τ_j	$\frac{195}{140.5} = 1.39$	0.73	1.03	

২য় লাইনে T_j দিয়ে নতুন করে forecast year ② পাবে

forecast year ③

P/A	z_1	z_2	z_3	Total
z_1	8.3	46.3	124.9	180
z_2	60.9	3.5	100.6	165
z_3	123.2	122.6	9.2	255
Total	192.9	172.9	234.7	
Goal	195	165	240	
τ_j				

base year-এ

① base-এ τ_i কে গুণ $T_{ij} = T_{ij} \times \tau_i$ দিয়ে forecast year ① বের করলে আমরা নতুন (A) → total attraction পাবো।

② নতুন forecast year ① এর A দিয়ে τ_j বের করে $T_{ij} = \tau_j \times T_{ij}$ দিয়ে forecast year ② পাবো

③ এভাবে একবার τ_i, একবার τ_j বের করে iteration করবো

forecast year ②

P/A	z_1	z_2	z_3	Total	Goal	τ_i
z_1	8.3	93.6	117.7	169.6	180	1.06
z_2	68.7	9	113.5	186.2	165	0.9
z_3	118.0	117.4	8.8	244.2	255	1.04
Total	195	165	240	600		

২য় লাইনে T_j এর value দিয়ে আগের মূল base এর fraction দিয়ে মূল করবো।

যেমন ⟹ $6 \times \frac{195}{140.5} = 8.3$

⟹ $49.5 \times \frac{195}{140.5} = 68.7$

⟹ $85 \times \frac{195}{140.5} = 118$ (change হয়ে 117.9 হয়েছে)

Gravity model :

Gravity model calibration → (Doubly constrained)

- Initial P/A matrix (base year) এবং impedence matrix থেকে থাকবে।
- impedence অনুযায়ী friction factor develop করে matrix বানাতে হবে।
- initially friction factor 1 ধরে base year

① বানাবো : সবজায়গায় ques এর base year value দিবো

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

$$\Sigma A_j \times f_{ij} = A_1 f_{i1} + A_2 f_{i2} + A_3 f_{i3}$$

$$ff_{new} = \frac{Observed}{estimated} \times ff_{old}$$

- iteration বলা থাকবে ques -এ

→ $|ff_{new} - ff_{old}| < 0.01$ or 0.001

Example :

base year

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

Travel time

Impedence

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

① Assuming, $f_{ij} = 1$

friction factor matrix ①

TT	z_1	z_2	z_3
z_1	1	1	1
z_2	1	1	1
z_3	1	1	1

② $\Sigma_j A_j \times f_{ij}$ (A_j = total attraction in zones) =

$A_1 \times f_{i1} + A_2 \times f_{i2} + A_3 \times f_{i3}$

$= 100 \times 1 + 150 \times 1 + 200 \times 1$

$= 450$

③ $T_{11} = P_1 \times A_1 \times f_{11} \div \Sigma A_j \times f_{ij}$ (A_1 = total attraction in zone 1)

$= 150 \times 100 \times 1 \div 450 = 33.33 \sim 33.3$

(P_1 = Total production in zone 1) Similarly, other T_{ij}'s were calculated

Base year ①

P \ A	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	600	

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④ friction factors ② → ques-2 (খ) base year থেকে নিতে হবে

TI	Estimated	Observed	FF
1-10	150	15	0.1
11-15	100	195	1.45
16-20	200	290	1.45

zone bin create করতে impedence matrix এর value নিতে হবে

TT(1-10) observed trip = 5+5+5 = 15

TT(1-10) estimated trip = 33.3+50+66.7 = 150

$ff_{new} = \frac{15}{150} \times 1 = 0.1$

ffmatrix 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

∴ $\sum_{11} A_j \times f_{ij}$ = নিতে হবে $A_1 \times f_{11(new)} + A_2 \times f_{12(new)} + A_3 \times f_{13(new)}$

$\sum_{21} A_j \times f_{ij} = A_1 \times f_{21} + A_2 \times f_{22} + A_3 \times f_{23} = 100 \times 1.45 + 150 \times 0.1 + 200 \times 1.45 = 450$

$= 100 \times 0.1 + 150 \times 1.45 + 200 \times 1.45 = 517.5$

$\sum_{31} A_j \times f_{ij} = A_1 \times f_{31} + A_2 \times f_{32} + A_3 \times f_{33} = 100 \times 1.45 + 150 \times 1.45 + 200 \times 0.1 = 382.5$

∴ $T_{11} = P_1 \times A_1 \times f_{11} \div \sum_{11}$ (new)

$= (150 \times 100 \times 0.1) \div 517.5 = 2.9$

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	

$T_{32} = P_3 \times A_2 \times f_{32} \div \sum_{31}$

$= (150 \times 150 \times 1.45) \div 382.5$

$= 85.3$

Gravity model application → (Doubly constrained)

- future এর P, A goal দেয়া থাকবে
- impedence → future generalized cost (দেয়া থাকবে)
- Calibrated friction factors দেয়া থাকবে

$T_{ij} = P_i \times A_j \times f_{ij} \div \sum A_j \times f_{ij}$

Example:

forecast year

P \ A	z_1	z_2	z_3	Goal
z_1				180
z_2				165
z_3				255
Goal	195	165	240	600

Impedance

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

friction factor

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

Solution:

① ff matrix ①

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

② $\Sigma_{11} = A_1 \times f_{11} + A_2 \times f_{12} + A_3 \times f_{13}$

$= 195 \times 0.1 + 165 \times 1.43 + 240 \times 1.43$

$= 598.7$

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

$= 195 \times 1.43 + 165 \times 1.51 + 240 \times 1.43 = 871.2$

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

$= 195 \times 1.43 + 165 \times 1.43 + 240 \times 0.1$

$= 538.8$

③ $T_{11} = P_1 \times A_1 \times f_{11} \div \Sigma_{11}$

$= 180 \times 195 \times 0.1 \div 598.7 = 5.9$

forecast year ①

P \ A	z_1	z_2	z_3	Total	Σ
z_1	5.9	70.9	103.2	180	598.7
z_2	52.8	47.2	65	165	871.2
z_3	132	111.7	11.3	255	538.8
Total	190.7	229.8	179.5	600	

আলাদা আলাদা করে নতুন ff matrix এবং নতুন forecast year ② বানাতে হবে।

নতুন forecast year ① থেকে পাবো

friction factor ② → ques এর obs use করতে হবে

TT	Est	Obs	FF
1-10	5.9+11.3 = 17.2	15	0.09
11-15	47.2	145	4.69
16-20	535.6	290	0.77

$ff_{new} = \frac{Obs}{Est} \times ff_{old}$

ff matrix ②

TT	z_1	z_2	z_3
z_1	0.09	0.77	0.77
z_2	0.77	4.64	0.77
z_3	0.77	0.77	0.09

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

$= 195 \times 0.09 + 165 \times 0.77 + 240 \times 0.77 = 329.4$

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

$= 180 \times 195 \times 0.09 \div 329.4$

$= 9.59$

forecast year ②

P \ A	z_1	z_2	z_3	Total	Σ
z_1	9.6	69.4	101	180	329.4
z_2	22.5	119.8	27.7	165	1101.55
z_3	128.1	106.4	18.5	255	298.8
Total	160.2	292.6	147.2	600	

③ Mode choice :

Logit model →

Utility maximization → (deterministic)

- formula দিয়ে দিবে

Example :

01.

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

Utility function, $U_K = (-0.2) \times \text{time} + (-1) \times \text{cost}$

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

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

$\therefore U_{bus} > U_{car}$ → choose bus

যদি utility বেশি কাকে নিবে

02.

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, $U_K = (-0.5) \times \text{time} + (-1) \times \text{cost}$

20x benefit

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

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

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

$\therefore U_{car} > U_{bus} > U_{home}$ → choose car

Random Utility maximization → (Probabilistic)

multinomial logit model (MNL) →

$$P_n(K|C_n) = P_{Kn} = \exp(V_K) \div \Sigma_{i \text{ in } C_n} \exp(V_i)$$

for 2 alternatives, (Utility)

$$P_1 = \exp(V_1) \div [\exp(V_1) + \exp(V_2)]$$

$$P_2 = \exp(V_2) \div [\exp(V_1) + \exp(V_2)]$$

example :

01.

Alternative	Time	Cost
Car	5 min	$5
bus	15 "	$2

$V_K = (-0.2) \times \text{time} + (-1) \times \text{cost}$

Scanned with CamScanner

Soln: probabilities of choosing each alternatives,

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

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

$\exp(V_{car}) = e^{-6} = 0.00298$

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

Sum = 0.00922

$\therefore$ Prob (Car) = 0.00298 ÷ 0.00922

= 0.269 = 26.9%.

Prob (bus) = 0.00674 ÷ 0.00922

= 0.731 = 73.1%.

Q2.

Alternative	Time	Cost
Car 1 (Uber)	5 min	$5
Car 2 (Lyft)	5 "	$5
Bus	15 "	$2

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

Soln: Probabilities of choosing alternatives,

$V_{car1} = -0.2 \times 5 + (-1) \times 5 = -6$

$V_{car2} = -0.2 \times 5 + (-1) \times 5 = -6$

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

$\therefore \exp(V_{car1}) = \exp(V_{car2}) = e^{-6} = 0.00298$

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

$\therefore$ Sum = 0.00298 + 0.00298 + 0.00674

= 0.0117

$\therefore$ Prob (Car1) = 0.00298 ÷ 0.0117 = 0.212

= 21.2% = Prob (Car2)

Prob (bus) = 0.00674 ÷ 0.0117 = 0.576

= 57.6%.

Nested logit model:

- m এর value ques a দিবে
- একটা veh এর সাথে আরেকটার হলে IV use করতে হবে veh এর জন্য.

$IV = m \times \ln[\exp(V_1 \div m) + \exp(V_2 \div m)]$

Example:

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

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$V_K = -0.2 \times \text{time} + (-1) \times \text{cost}$

$m = 0.15$

Soln:

Probabilities of choosing alternatives

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

$V_{bus1} = -0.2 \times 15 + (-1) \times 2 = -5$

$V_{bus2} = -0.2 \times 15 + (-1) \times 2 = -5$

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

~~$\exp(V_{bus1}) = \exp(V_{bus2}) = e^{-5} = 0.00674$~~

সমান বিবেচনা।

$\therefore IV_{bus} = m \times \ln[\exp(V_{bus1} \div m) + \exp(V_{bus2} \div m)]$

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

$= -4.896$

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

$\exp(IV_{bus}) = e^{-4.896} = 0.00748$

Sum = 0.00996

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

$= 0.00248 \div 0.00996 = 0.249$

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

$= 0.00748 \div 0.00996$

$= 0.75$

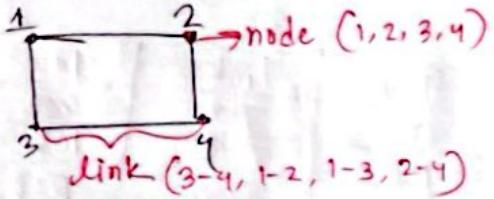
④ Trip assignment:

Uncongested condition →

1. ~~All or nothing assignment~~ → (AoN)

→ ~~বিভিন্ন~~ link-এ flow হবে সমানুপাতিক হারে।

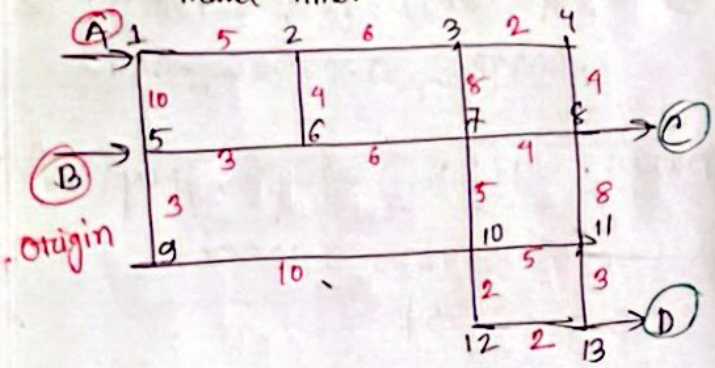
– OD matrix (Origin Destination) লাগে।



Example:

Origin \ Destination	A	B	C	D
A	0	0	400	200
B	0	0	300	100
C	0	0	0	0
D	0	0	0	0

Travel times



① Shortest paths for,

A → C = 1-2-3-4-8 → 17 min

A → D = 1-2-6-7-10-12-13 → 24 min

B → C = 5-6-7-8 → 13 min

B → D = 5-9-10-12-13 → 17 min

②

Link	flow	Link	flow
1-2	600	7-8	300
2-3	400	5-9	100
3-4	400	7-10	200
1-5	0	8-11	0
2-6	200	9-10	100
3-7	0	10-11	0
4-8	400	10-12	300
5-6	300	11-13	0
6-7	500	12-13	300

Congested condition →

User equilibrium → Wardrop's principles use করা হয়

- route number, total vehicles, travel time function দেয়া থাকবে। কোন route কতো vehicle নিবে তা বের করতে

x → traffic volume in 1000 veh

Example:

① $TT_1(x_1) = 6 + 4x_1$

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

∴ flow constraints ; $x_1 + x_2 = x = \frac{4500}{1000} = 4.5$

$\Rightarrow x_1 + x_2 = 4.5$

② Check if both routes will be used

1. AON on route 1 $(x_1 = 4.5, x_2 = 0)$

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

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

$TT_2 < TT_1$

2. AON on route 2 $(x_1 = 0, x_2 = 4.5)$

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

$TT_2(4.5) = 4 + (4.5)^2 = 24.25$ min

∴ both routes will be used

(3) At use equilibrium,

1. $TT_1(x_1) = TT_2(x_2)$

$\Rightarrow 6 + 4x_1 = 4 + (x_2)^2$ ——— (I)

2. flow constraints : $x_1 + x_2 = 4.5$ ——— (II)

$x_1 = 4.5 - x_2$

from (I),

$6 + 18 - 4x_2 = 4 + x_2^2$

$\Rightarrow x_2^2 + 4x_2 - 20 = 0$

$\Rightarrow x_2 = 2.9$ or -6.9

$\therefore x_2 = 2.9 < 4.5$

$\therefore x_1 = 4.5 - 2.9 = 1.6$

$\therefore x_1 =$ 1600 veh / hour

$x_2 =$ 2900 veh / hour

check for equal travel time,

$TT_1(1.6) = 6 + 4 \times 1.6 = 12.4$ min

$TT_2(2.9) = 4 + (2.9)^2 =$ 12.4 min

Previous year :

3(c)(i)

zone, total generated trips: $275 \times 5 + 275 \times 2.5 = 2062.5$ trips

if all household have a car,

total future trip $= 550 \times 5 = 2750$ trips

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