IAT-II : Questions and Answers
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1(a) How are trips categorized?

Trips can be classified by trip purpose, trip time of the day, and by person type.
The trips can be classified based on the purpose of the journey as trips for work, trips for education, trips for shopping, trips for recreation and other trips. Among these the work and education trips are often referred as mandatory trips and the rest as discretionary trips. All the above trips are normally home based trips and constitute about 80 to 85 percent of trips. The rest of the trips namely non home based trips, being a small proportion are not normally treated separately.
The second way of classification is based on the time of the day when the trips are made. The broad classification is into peak trips and off peak trips.
The third way of classification is based on the type of the individual who makes the trips. This is important since the travel behavior is highly influenced by the socio economic attribute of the traveler and are normally categorized based on the income level, vehicle ownership and house hold size.

b. What are the assumptions made in multilinear regression model of trip generation?

- All the variables are normally distributed
- All the variables are continuous
- A linear relationship exists between dependent and independent variables
- Inclusion of each variable in the equation contributes a distinct portion of the trip numbers.

It is difficult to ensure that all the assumptions are satisfied in trip generation models. The variables car ownership, income, family size are interrelated to certain extent. So, independent variables are not truly independent of each other
Many of the variables are not normally distributed
All variables are not continuous. For example, car ownership. Number of cars owned by a family can only be a discrete variable.

(c) What are the criteria to evaluate regression equations in trip generation model?

- The multiple correlation coefficient should have a value at least 0.75 or higher. A value close to 1.0 shows very good correlation.
- The standard error of the estimate of dependent variable should be small.
- The F test should be carried out to examine the evidence of the degree of certainty that a meaningful relationship exists between dependent and independent variables.
- The equation should have accuracy, validity, simplicity and sharpness.

3. (a) Explain the growth factor model used in trip generation.

Growth factor modes tries to predict the number of trips produced or attracted by a house hold or zone as a linear function of explanatory variables. The models have the following basic equation:

$T_i = f_i t_i$

where Ti is the number of future trips in the zone i, and t_i is the number of current trips in that zone and fi is a growth factor.

The growth factor f_i depends on the explanatory variable such as population (P) of the zone,

average house hold income (I), average vehicle ownership (V). The simplest form of f_i

is represented as follows

$$f_i = \frac{P_i^d \times I_i^d \times V_i^d}{P_i^c \times I_i^c \times V_i^c}$$

where the superscript" d" denotes the design year"c" denotes the current year.

3 (c) What are the advantages and disadvantages of category analysis?

Advantages

i) Cross-classification groupings are independent of the zone system of the study area.
ii. No prior assumptions about the shape of the relationship are required (i.e. they do not even have to be monotonic, let alone linear.)
iii. Relationships can differ in form from class to class (e.g. The effects in changes in the household size for one or two car owning households may be different).

Disadvantages

- It is difficult to test the statistical significance of various explanatory variables.
- The technique makes use of studies in the past made elsewhere, with broad corrections.
- Large samples are needed to assign trip rate to any one category
- New variables can not be introduced at a future date
- In the analysis it is assumed that income and car ownership increase in future. The categories of higher income and higher car ownership are however the ones which are least represented in the base year. Moreover, they are the ones most likely to be used for future estimates of trip generation.

6 (a) What are the disadvantages of growth factor models in trip distribution?

- It will tend to overestimate the trips between densely developed zones, which probably have little development potential,
- Underestimate the future trips between underdeveloped zones, which are likely to be extremely developed in the future.
- It will also fail to make provision for zones which are at present undeveloped and which may generate a considerable number of trips in the future.
- Large number of iterations are required then the accuracy of the resulting trip matrix may be questioned.

6 (b) Explain the gravity model in trip distribution and discuss about its calibration

One of the well known synthetic models is the Gravity Model. Based in Newton's concept of gravity, the model as proposed by Voorhees assumes that the interchange of trips between zones in an area is

dependent upon the relative attraction between the zones and the spatial separation between them(ie, distance).
The trip interchange is directly proportional to the relative attraction between the zones, it is inversely proportional to the distance between zones.

A simple equation representing the above relationship is of the following form:

$$T_{i-j} = \frac{KP_i A_j}{d_{ij}^n}$$

Where,

T_{i-j} = Trips between zones i and j
P_i = Trips produced in zone i
A_j = Trips attracted to zone j
d_{ij} = Distance between zone i and j, or the time or cost of traveling between them
K = A constant, usually independent of i
n = An exponential constant, whose value is usually found to lie 1 and 3
k = Total number of zones

The following formulation was also used in earlier studies dispersing with the proportionality constant:

Calibration of gravity model
Calibration is the process of determining the travel time factor Fi-j which expresses the area-wide effect of spatial separation on trip interchange between zones and the factor Ki-j which is the specific zone to zone adjustment factor to account for social and economic factors influencing the travel pattern.
The following phases are involved in travel pattern
Phase1 – In this phase the basic data on the area's travel pattern and transportation facilities are processed to provide 3 basic input to gravity model formula, which are zonal trip production, attraction and distance between the zones as measured by travel time. The network is studied and driving time and terminal times are determined. The inter- zonal and intra zonal travel times are derived.
Phase 2 – The basic survey trip data are analyzed and a table of zone to zone movement for each trip purpose is built. The effect of trip length on trip making is studied by obtaining the trip length frequency distribution by one minute travel time increments, for each trip purpose is being analysed.
Phase 3 – This phase relates to the development of travel time factors. Initially set of travel time factors are assumed. Trip interchanges are calculated using gravity model formula on the basis of data on zonal trip production and attractions, minimum path travel time and assumed travel time factors. The initial estimate of trip interchange is then combined with the minimum time paths to obtain an estimated trip length frequency distribution for each trip purpose category. A comparison of actual and estimated trip length frequency distribution is made and successive iterations are done to get close agreement between two.

Phase 4- In this phase zone to zone adjustment factors (Ki-j) are developed to account for social and economic linkages. Topographical barriers like rivers are eliminated by adjustment to minimum path travel time.
Phase5- The calibrated model is tested to ensure that it simulates existing travel pattern accurately.

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Trips per day (y)	HH size (x) ①	②	③	④
	1	3	4	5
	3	4	5	8
	3	5	7	8
Σy	7	12	16	21

$\Sigma y = 56$.

$\Sigma x = 3\times1 + 3\times2 + 3\times3 + 3\times4 = 30$

$\Sigma x^2 = 3\times1^2 + 3\times2^2 + 3\times3^2 + 3\times4^2 = 90$

$\Sigma xy = 1\times1 + 1\times3 + 1\times3 +$
$2\times3 + 2\times4 + 2\times5 +$
$3\times4 + 3\times5 + 3\times7 +$
$4\times5 + 4\times8 + 4\times8 = 163$

$\bar{x} = \frac{\Sigma x}{n} = \frac{30}{12} = 2.5$

$\bar{y} = \frac{\Sigma y}{n} = \frac{56}{12} = 4.67$

$\bar{y} = a + b\bar{x}$ ——— (1)

$b = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} = \frac{12\times163 - 30\times56}{12\times90 - (30)^2} = 1.53$

Subs in eqn (1)

$4.67 = a + 1.53\times2.5 \Rightarrow a = 0.845$

$y = 0.845 + 1.53x$, If $x = 3.25$, y = trip rate $= 5.8$ say 6 Trips/day

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Answers

(3) b) HH with car = 275, trips 5/day

" without car = 275, trips 2.5/day

current trip rate $t_i = 275 \times 2.5 + 275 \times 5 = 2062.5$ trips/da

$$G.F = f_i = \frac{V_i^d}{V_i^c} = \frac{550}{275} = 2.0$$

Number of future trips $= T_i = F_i t_i = 2 \times 2062.5$

$= 4125$ trips/day

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(4)

Zone	1	2	3	Total
P_i	14	33	28	75
A_j	33	28	14	75

$$T_{ij} = \frac{P_i A_j F_{i-j}}{\sum_j A_j F_{i-j}}$$

$$T_{1-1} = \frac{14 \times 33 \times 13}{33 \times 13 + 28 \times 82 + 14 \times 41} = \frac{6006}{3299} = 1.82$$

$$T_{1-2} = \frac{14 \times 28 \times 82}{3299} = 9.74$$

$$T_{1-3} = \frac{14 \times 14 \times 41}{3299} = 2.44$$

$$T_{2-1} = \frac{33 \times 33 \times 50}{33 \times 50 + 28 \times 26 + 14 \times 39} = \frac{54450}{2924} = 18.62$$

$$T_{2-2} = \frac{33 \times 28 \times 26}{2924} = 8.22$$

$$T_{2-3} = \frac{33 \times 14 \times 39}{2924} = \frac{18018}{2924} = 6.16$$

(PTO)

$$T_{3-1} = \frac{28 \times 33 \times 52}{33 \times 52 + 28 \times 20 + 14 \times 41} = \frac{48048}{2850} = 16.8$$

$$T_{3-2} = \frac{28 \times 28 \times 20}{2850} = \frac{15680}{2850} = 5.5$$

$$T_{3-3} = \frac{28 \times 14 \times 41}{33 \times 52 + 28 \times 20 + 14 \times 41} = 5.6$$

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(5) $$T_{A-B} = t_{A-B} \left(\frac{P_A}{p_A}\right)\left(\frac{A_B}{a_B}\right)\left(\frac{t_{AB} + t_{AC} + t_{AD}}{t_{AB} \times E_B + t_{AC} E_C + t_{AD} E_D}\right)$$

$$= 10 \left(\frac{80}{40}\right)\left(\frac{114}{38}\right)\frac{(10+12+18)}{(10 \times 3 + 12 \times 1.5 + 18 \times 1)} = 36.36$$

$$T_{A-C} = 12 \left(\frac{80}{14}\right)\left(\frac{48}{32}\right)\frac{40}{66} = 21.81$$

$$T_{A-D} = 18 \left(\frac{80}{40}\right)\left(\frac{38}{38}\right)\frac{40}{66} = 21.8$$

$$T_{B-A} = 10\left(\frac{114}{38}\right)\left(\frac{80}{40}\right)\frac{(10+14+14)}{(10 \times 2 + 14 \times 1.5 + 14 \times 1)} = 41.45$$

$$T_{B-C} = 14 \left(\frac{114}{38}\right)\left(\frac{48}{32}\right) \left(\frac{38}{55}\right) = 43.5$$

$$T_{B-D} = 14\left(\frac{114}{38}\right)\left(\frac{38}{38}\right)\left(\frac{38}{55}\right) = 29.0$$

$$T_{C-A} = 12 \left(\frac{48}{32}\right)\left(\frac{80}{40}\right)\frac{(12+14+6)}{(12 \times 2 + 14 \times 3 + 6 \times 1)} = 16$$

$$T_{C-B} = 14\left(\frac{48}{32}\right)\left(\frac{114}{38}\right) \times \frac{32}{72} = 28$$

$$T_{C-D} = 6\left(\frac{48}{32}\right)\left(\frac{38}{38}\right)\frac{(12+14+6)}{72} = 4$$

$$T_{D-A} = 18\left(\frac{38}{38}\right)\left(\frac{80}{40}\right)\frac{(18+14+6)}{18\times2+14\times3+6\times1.5} = 15.7$$

$$T_{D-B} = 14\left(\frac{38}{38}\right)\left(\frac{114}{38}\right)\frac{(18+14+6)}{18\times2+14\times3+6\times1.5} = 18.3$$

$$T_{D-C} = 6\times1\times\left(\frac{48}{32}\right)\left(\frac{38}{87}\right) = 3.9$$

Summary

Zone	A	B	C	D	Sum of Prod of trips & GF	Desired Trip	Ratio
GF	2	3	1.5	1			
Zone A							
1	–	10	12	18			
2	–	30	18	18	66	80	1.21
3	–	36.4	21.8	21.8	80		
Zone B							
1	10	–	14	14			
2	20	–	21	14	55	114	2.07
3	41.5	–	43.5	29	114		
Zone C							
1	12	14	–	6			
2	24	42	–	6	72	48	0.667
3	16	28	–	4	48		
Zone D							
1	18	14	6	–			
2	36	42	9	–	87	38	0.437
3	15.8	18.3	3.9	–	38		