Module 4

2.1 Transportation Planning Process

The transportation planning process has a lot of similarity to the problem solving process. The following table gives the major differences between the two processes.

Sl No	**Problem Solving**	**Transportation Planning**
1	Problem solving lacks foresight ness to take advantage of the forthcoming innovations	Problem definition and Objective relevant to planning condition. They change themselves, so innovations are used
2	It is not Programmed Basis	Usually Programmed basis
3	Our concern may be for the dimension and performance of a vehicle to be replaced within a shorter period of time from now	We may be concerned with about location and capacity of Mass Transit
4	Breadth of problem: i.e. parking, congestion	Study of broader situation i.e. whole city
5	Immediate solution is required .so it is completed within shorter period	Implemented Sequentially

2.2 Types of Planning Methodologies

1. Projective planning.
2. Deductive planning.
3. Objective planning.

Projective planning:

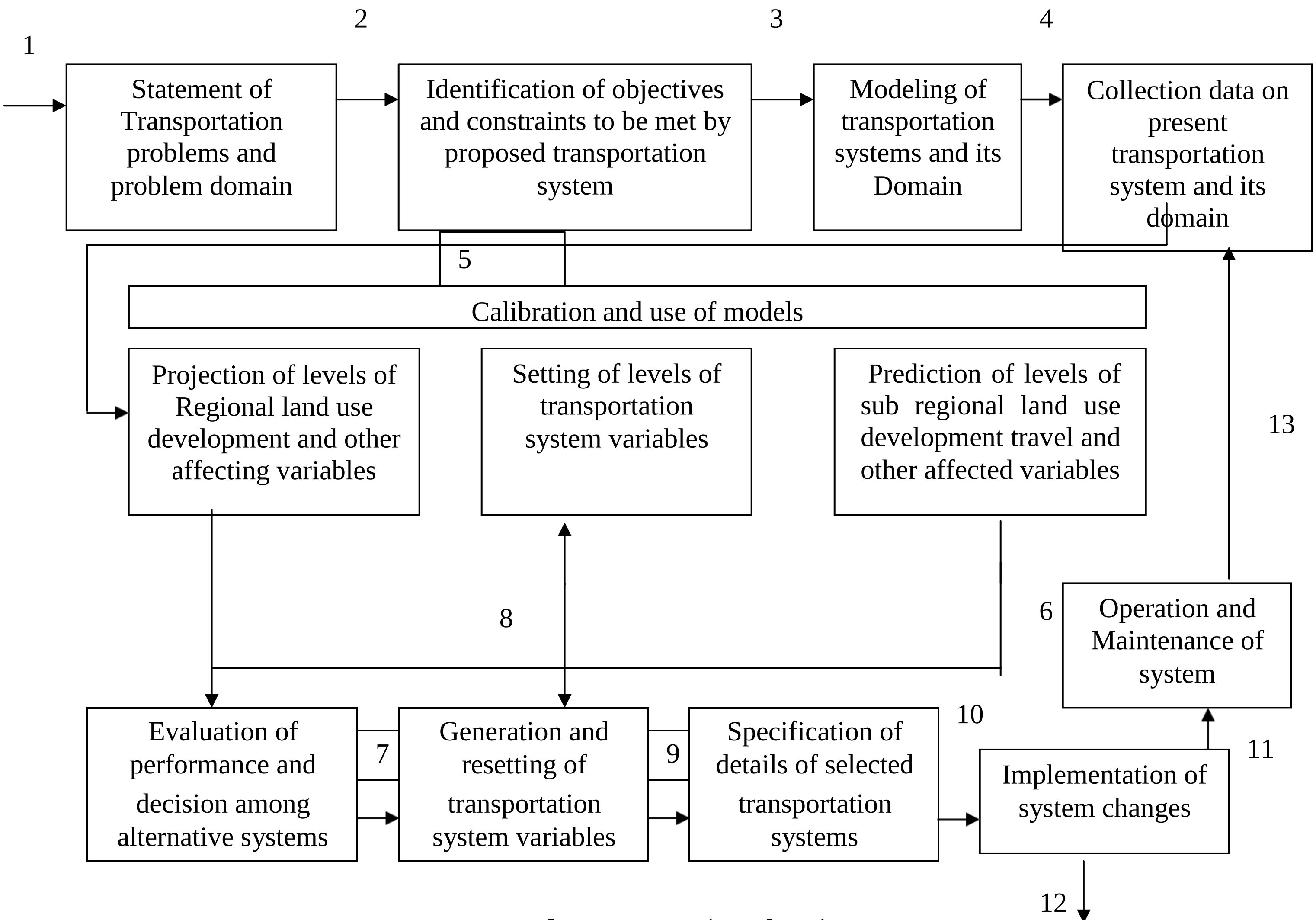
It is a base for planning. It is an open Extrapolation method.

Example: Traffic flows, Vehicle ownership, Residential Densities, Population trends, Economic Growth, Socio- economic indices.

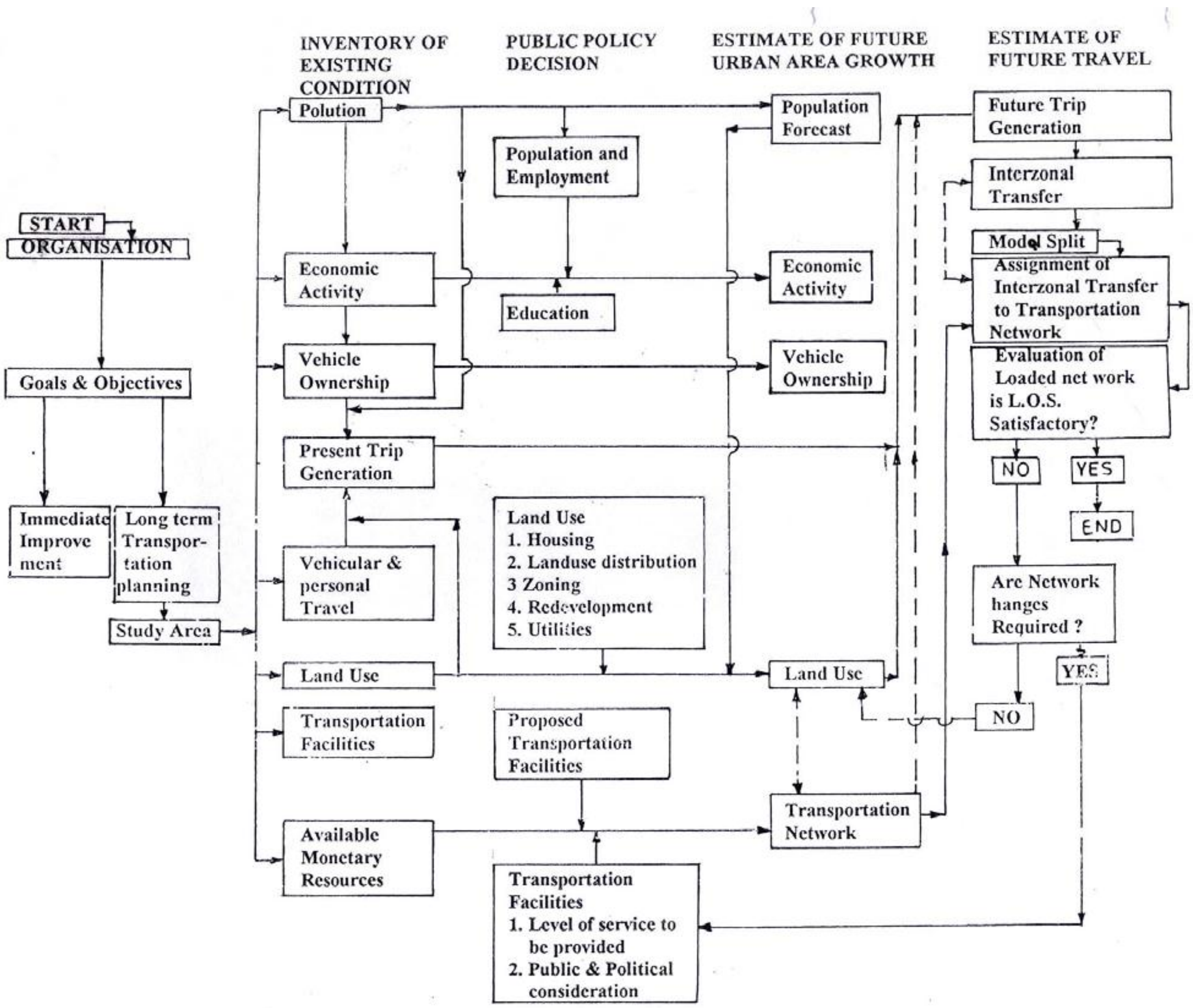
Deductive planning: Synthesis the future state of the system from laws, equations or models that are one in its behaviour.

Example: Analysis of specific projects and operational activities such as bypasses, regional centers, transport terminals, one-way streets can be effectively analyzed deductive planning process.

Objective planning: Planner sets some goals and with a certain objective and with constraints. It will be difficult to take into account the uncertainties.



Total Transportation planning process

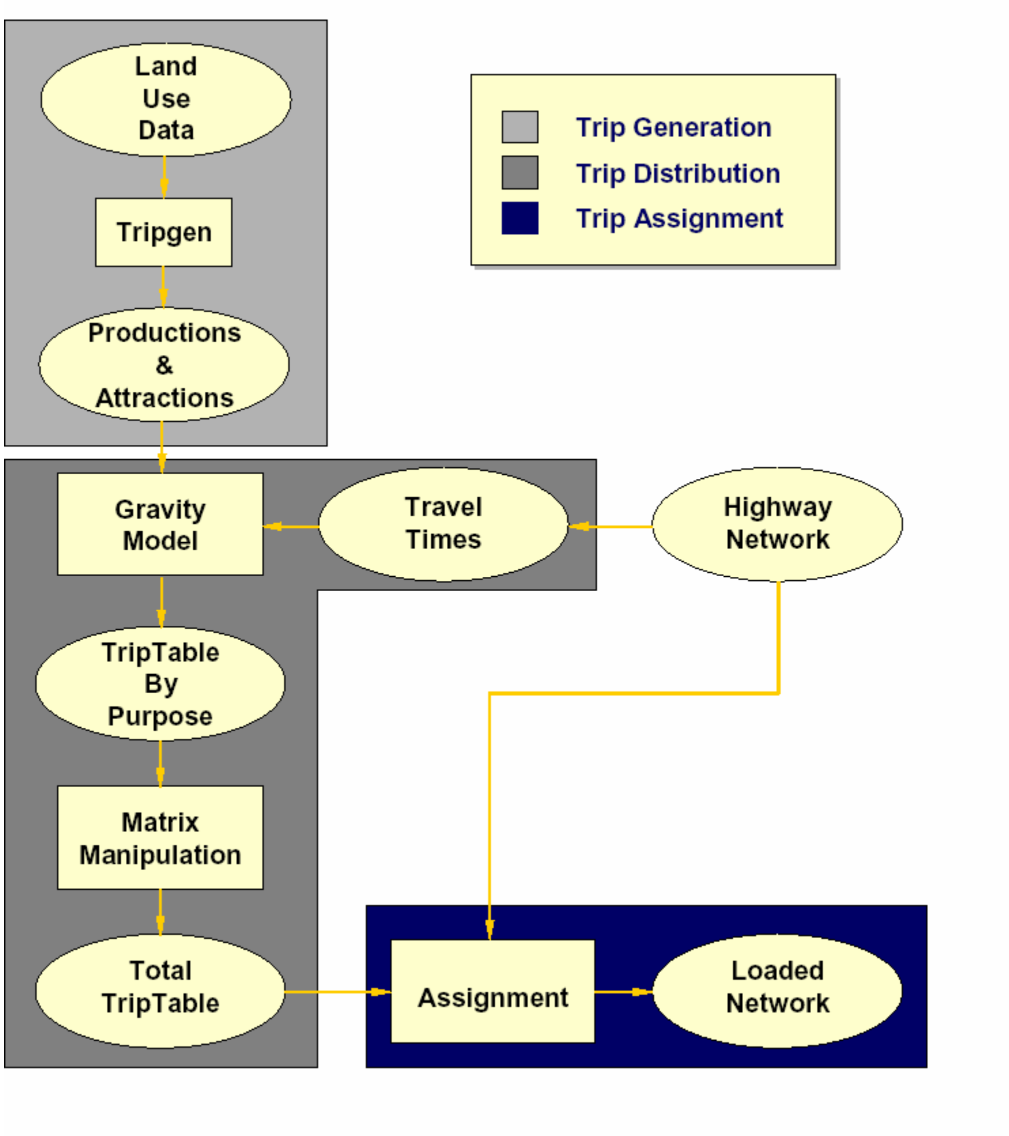


Deductive Planning Process

2.3 Travel demand modelling:

There are four steps of travel demand modelling. They are

1. Trip generation
2. Model split
3. Trip Distribution
4. Trip assignment



Steps of Travel Demand Modelling

2.3.1 Trip-Generation Analysis: -Two types of trip-generation analysis are carried out and these are trip production and trip attraction.

Trip Production: -is reserved for trips generated by residential zones where these trips may be trip origins and destinations.

Trip Attraction: -is used to describe trips generated by activities at the non-home end of a home-based trip such as employment, retail service, and so on.

The first activity in travel-demand forecasting is to identify the various trip types important to a particular transport-planning study. The trip types studied in a particular area depend on the types of transport-planning issues to be resolved. The first level of trip classification used normally is a broad grouping into home-based and non-home-based trips.

Home-based Trips: - are those trips that have one trip end at a household. Examples journey to work, shop, school etc.

Non-home-based trips: -are trips between work and shop and business trips between two places of employment.

Trip classification that have been used in the major transport-planning studies for home-based trips are:

a. Work trips
b. School trips
c. Shopping trips
d. Personnel business trips, and
e. Social-recreational trips

Factors influencing Trip Production

Households may be characterized in many ways, but a large number of trip-production studies have shown that the following variables are the most important characteristics with respect to the major trip trips such as work and shopping trips:

1. The number of workers in a household, and
2. The household income or some proxy of income, such as the number of cars per household.

Factors Influencing Trip Attraction

Depending on the floor areas, the trip attraction can be determined from retail floor area, service and office floor area and manufacturing and wholesaling floor area.

Multiple Regression Analysis

The majority of trip-generation studies performed have used multiple regression analysis to develop the prediction equations for the trips generated by various types of land use.

Most of these regression equations have been developed using a stepwise regression analysis computer program. Stepwise regression –analysis programs allow the analyst to develop and test a large number of potential regression equations using various combinations and transformations of both the dependent and independent variables. The planner may then select the most appropriate prediction equation using certain statistical criteria. In formulating and testing various regression equations, the analyst must have a thorough understanding of the theoretical basis of the regression analysis.

Review of Regression Analysis Concept

Some of the fundamental of regression analysis: - The principal assumptions of regression analysis are:

1. The variance of the Y values about the regression line must be the same for all magnitudes of the independent variables.
2. The deviations of the Y values about the regression line must be independent of each other and normally distributed.
3. The X values are measured without error
4. The regression of the dependent variable Y on the independent variable X is linear.

Assume that observation of the magnitude of a dependent variable Y have been obtained for N magnitudes of an independent variable X and that on an equation of the form $Y_e = a + bX$ is to be fitted to the data where Y_e is an estimated magnitude rather than an observed value Y.

From the least-squares criterion, the magnitude of the parameters a and b may be estimated.

$$b = \frac{\sum xy}{\sum x^2}$$

$$a = \overline{Y} - b\overline{X}$$

where

$$x = X - \overline{X} \quad \text{and} \quad y = Y - \overline{Y}$$

$\overline{X}$,$\overline{Y}$ =the means of the X and Y observations respectively.

$$\sum y^2 = \sum y_d^2 + \sum y_e^2$$

Where

$\sum y^2$ = total sum of the squares of the deviations of the Y observations about the mean value

$\sum y_d^2$ =the sum of the squares of the deviations of the Y observations from the regression line.

$\sum y_e^2$ =the sum of the squares of the deviations of the estimated Y_e magnitude about the mean value.

The ratio of the sum of the squares explained by the regression to the total sum of squares is known as *the coefficient of determination and denoted by* r^2.

$$r^2 = \frac{\sum y_e^2}{\sum y^2} \qquad 0 \le r^2 \le 1$$

- if r^2 =1 implies no variation remaining that is unexplained by the independent variable used in the regression.
- If r^2 = 0 implies the independent variable used would not explain any of the observed variation in the dependent variable.

The square root of the coefficient of determination is termed as the *correlation coefficient.*

A second useful measure of the validity of a regression line is the standard error of the estimate, which is estimated from:

$$s_e = \sqrt{\frac{\sum y_d^2}{(N-2)}}$$

where

$(N - 2)$ is the degree of freedom associated with the sum of squares $\sum y_d^2$

The regression coefficient *b* is the statistical estimate and is therefore subject to error.

$$s_b = \frac{s_e}{s_X}\sqrt{N}$$

where

s_X is the standard deviation of the independent variable.

Statements about the confidence that might be placed in an estimated coefficient is given by:

$$t = \frac{\text{regression coefficient}}{\text{standard error of the regression coefficient}}$$

Partial or Multiple Regression Equation

It has equation of the form:

$$Y_e = a + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p$$

where there are *p* independent variables and the regression coefficients $b_1, \; b_2, \ldots, b_p$ are referred to as *partial regression coefficients*.

The coefficient of multiple determinations, $R^{2\;2}$ is given by:

$$R^2 = \frac{\sum (Y_e - \overline{Y})^2}{\sum (Y - \overline{Y})^2}$$

where R^2 is known as the multiple correlation coefficients.

$$s_e = \frac{\sum y_e^2}{[N - (P + 1)]}$$

$$s_b = \frac{s_e^2}{[s_{Xi}^2 N(1-R_{Xi}^2)]}$$

Where s_{Xi} is the standard deviation of the independent variable X_i and R_{Xi} is the coefficient of multiple correlations between X_i and all other independent variables.

Table 1: Linear Regression

Y	X	$y = Y - Y$	$x = X - \overline{X}$	xy	x^2
9428	9482	7502.125	7473.375	56066193.42	55851334
2192	2010	266.125	1.375	365.921875	1.890625
330	574	-1595.88	-1434.63	2289482.172	2058149
153	127	-1772.88	-1881.63	3335885.922	3540513
3948	3836	2022.125	1827.375	3695180.672	1827.375
1188	953	-737.875	-1055.63	778919.2969	-1055.63
240	223	-1685.88	-1785.63	3010340.547	-1785.63
55	36	-1870.88	-1972.63	3690534.797	-1972.63
2064	2223	138.125	214.375	29610.54688	214.375
280	272	-1645.88	-1736.63	2858267.672	-1736.63
52	50	-1873.88	-1958.63	3670218.422	-1958.63
230	209	-1695.88	-1799.63	3051939.047	-1799.63
420	410	-1505.88	-1598.63	2407329.422	-1598.63
9654	11023	7728.125	9014.375	69664216.8	9014.375
450	527	-1475.88	-1481.63	2186693.297	-1481.63
130	183	-1795.88	-1825.63	3278594.297	-1825.63

$\overline{Y}$	$\overline{X}$				
1925.875	2008.625			Σ=160013772.3	Σ=61445839
b	2.604143	a	-3304.87		

Category analysis:

Category analysis is a technique for estimating the trip production characteristics of households, which have been sorted into a number of separate categories according to a set of properties that characterize the household. Category analysis may also be used to estimate trip attractions.

Zonal trip productions may be estimated as

$$p_i^q = \sum h_i(c)tp(c)$$

Where,

p_i^q = The number of trips produced by zone i by type q people.

$h_i(c)$= number of households in zone i in category c

tp(c)= trip production rate of a household category c.

Zonal trip-attractions may be estimated as

$$a_j = \sum b_j(c)ta(c)$$

Where,

a_j = number of work trips attracted by zone j.

$b_j(c)$ = number of employment opportunities in category c.

ta(c) = trip attraction rate of employment category c

And the summation is over all employment types if work trip attractions are to be estimated.

2.3.2 Modal Split

The second stage of travel demand forecasting process has bee identified as captive modal split analysis. The second stage of modal split analysis was identified as occurring after the trip distribution analysis phase. Two submarkets for public transportation services have been labelled as captive transit riders and choice transit riders. The aim of captive modal split analysis is to establish relationships that allow the trip ends estimated in the trip generation phase to be partitioned into captive transit riders and choice transit riders. The purpose of choice modal split analysis phase is to estimate the probable split of choice transit riders between public transport and car travel given measures of generalized cost of travel by two modes.

The ratio of choice trip makers using a public transport system varies from 9 to 1 in small cities with poorly developed public transport systems to as high as 3 to 1 in well developed cities.

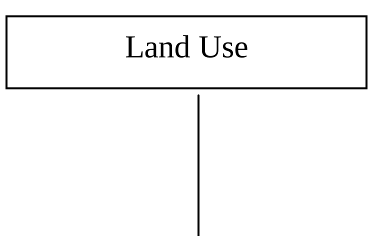
Major determinants of Public Patronage are

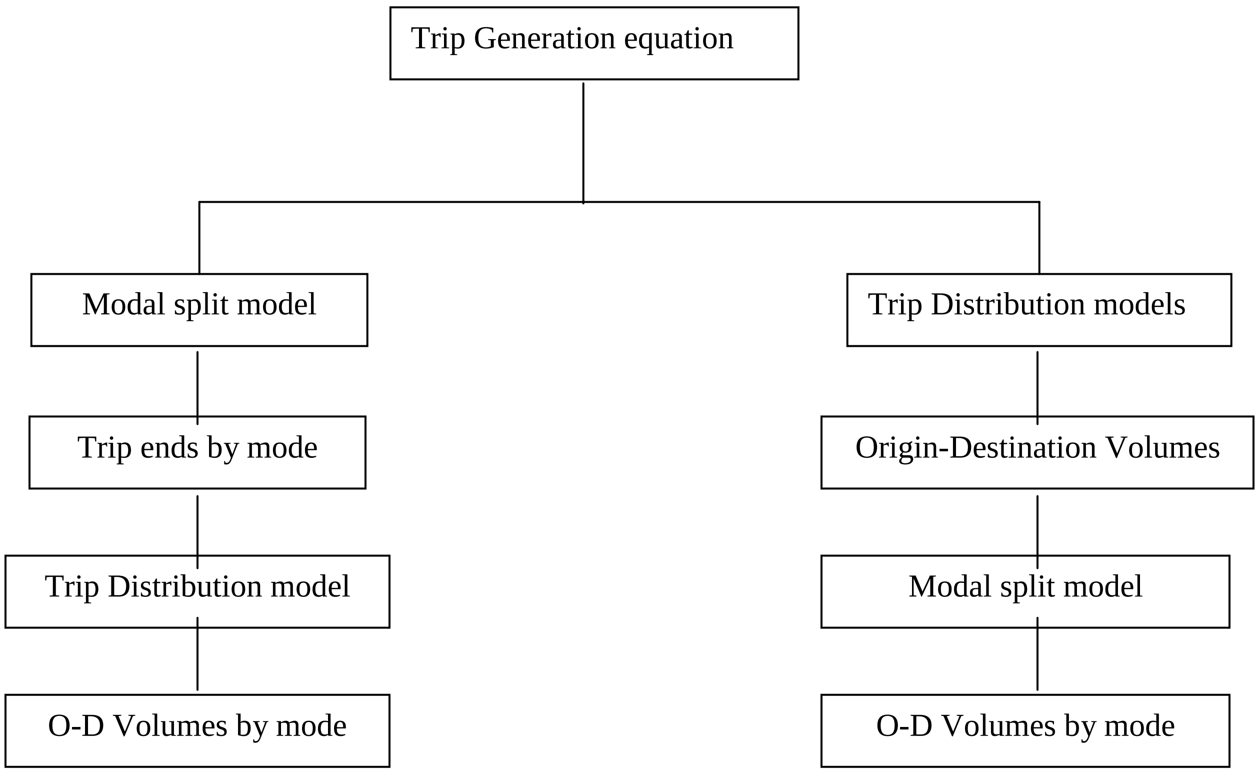
1. Socio economic characteristics of trip makers
2. Relative cost and service properties of the trip by car and that by public transport.

Variables used to identify the status at the household level are

1. Household income or car ownership directly
2. The number of persons per household.
3. The age and sex of household members.
4. The purpose of the trip.

The modal split models, which have been used before the trip distribution phase, are usually referred to as trip end modal split models. Modal split that have followed the trip distribution phase are normally termed trip interchange modal spit models. Trip end modal split models are used today in medium and small sized cities. The basic assumption of the trip end type models is that transport patronage is relatively insensitive to the service characteristics to the transport modes. Modal patronages are determined principally by the socio economic characteristics of the trip makers. Most of the trip interchanges modal split models incorporate measures of relative service characteristics of competing modes as well as measures of the socio economic characteristics of the trip makers. The modal split model developed during the southeastern Wisconsin transportation study is an example of trip end type model. The model-split model developed in Toronto is an example of trip interchange modal split model.





Trip End Type Modal Split Model **Trip Interchange Type Modal Split Model**

These factors, including time and cost, can be grouped into three broad categories.

- Characteristics of the traveler -- the trip maker;
- Characteristics of the trip; and
- Characteristics of the transportation system.

2.4 TRIP DISTRIBUTION

A trip distribution model produces a new origin-destination trip matrix to reflect new trips in the future made by population, employment and other demographic changes so as to reflect changes in people's choice of destination. They are used to forecast the origin-destination pattern of travel into the future and produce a trip matrix, which can be assigned in an assignment model of put into a mode choice model. The trip matrix can change as a result of improvements in the transport system or as a result of new developments, shops, offices etc and the distribution model seeks to model these effects so as to produce a new trip matrix for the future travel situation.

Trip distribution models connect the trip origins and destination estimated by the trip generation models to create estimated trips. Different trip distribution models are developed for each of the trip purposes for which trip generation has been estimated.Various techniques developed for trip distribution modeling are

- Growth Factor Models
- Synthetic Models

Growth Factor Models

- Uniform Factor Method
- Average Factor Method
- Detroit Method
- Fratar Method
- Furness Method
- Furness Time-function Iteration

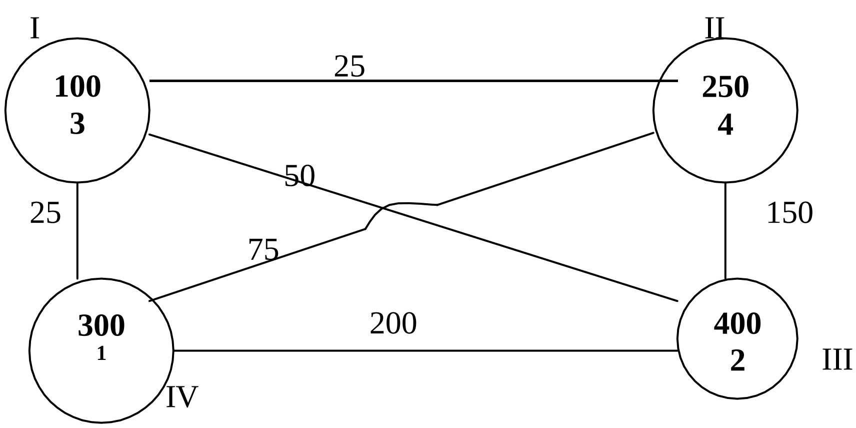
Synthetic Models

- Gravity/Spatial Interaction Models
- Opportunity Models
- Regression/Econometric Models
- Optimization Models

2.4.1 Growth Factor Models

1. Uniform Growth Factor Model

A single growth factor for the entire area under study is calculated by dividing the future number of trip ends for the horizon year by trip ends in the base year. The future trips between zones I and j are then calculated by applying the uniform factor to the base year trips between zones i and j.



The origin and destination matrix can used to represent the given network.

	I	II	III	IV
I	0	25	50	25
II	25	0	150	75
III	50	150		200
IV	25	75	200	

From the above origin-destination matrix, we can the following in matrix form.

	I	**II**	**III**	**IV**	**ti**	**Fi**	**Ti**	**Tcal**
I		25	50	25	100	300	300	229
II	25		150	75	250	1000	1000	571
III	50	150		200	400	300	800	914
IV	25	75	200		300	300	300	686
Tj	300	1000	800	300	1050		2400	2400

Uniform growth factor $F^{(1)}$ = 2400/1050 = **2.286**

Tcal is tabulated using the calculated growth factor in the last column.

Uniform growth factor $F^{(2)}$ = 2400/1050 = **2.286**. Since the growth factors remain equal, there is no need of further iteration

There are some drawbacks of using this method. These are:

1. The assumption of a uniform growth rate for the entire study area is not correct as the growth factor varies across zones.
2. The land use pattern changes with time, but not uniformly as assumed. Hence growth factor changes with time.

2. Average Growth Factor Model:-

In this method, the growth factor represents the average growth associated with both the origin and destination zones. If Fi and Fj are the growth factors for the zones I and j respectively, then:

$$T_{ij} = \frac{t_{ij}(F_i + F_j)}{2}$$

Where Fi = Ti/ti and Fj = Tj/tj

After the first distribution, it may be found that the sum of the trips from zones are not equal to the projected trip ends for the respective zones. This discrepancy has then to be removed by successive iterations as:

$$F_i' = T_i/t_i' \text{ and } F_j' = T_j/t'_j$$

where ti' and tj' are the generation and attraction of zone I and j respectively obtained from the first stage of distribution. This can be illustrated using the network given Above

Iteration 1: -T11 =0(3+3)/2 =0 T12=25(3+4)/2=87 and so on

	I	II	III	IV	ti'	Ti	Fi'
I		87	125	50	262	300	1.145
II	88		450	187	725	1000	1.379
III	125	450		300	875	800	0.914
IV	50	188	300		538	300	0.5576
tj'	263	725	875	537	2400		
Tj	300	1000	800	300		2400	
Fj'	1.145	1.379	0.914	0.5576			

Iteration 2: -The second iteration can be done in tabular form also.

	I	II	II	IV	ti''	Ti	Fi''
I		110	129	43	282	300	1.064
II	111		516	181	808	1000	1.2376
III	129	516		221	866	800	0.9238
IV	42	182	220		444	300	0.5576
tj''	282	808	865	445			0.6756
Tj	300	1000	800	300		2400	
Fj''	1.064	1.2376	0.9238	0.6756			

Iteration 3: -The third iteration can be done in tabular form also.

	I	II	III	IV	ti'''	Ti	Fi'''
I		128	128	37	293	300	1.024
II	128		557	174	859	1000	1.164
III	128	557		177	862	800	0.929
IV	36	174	176		386	300	0.5576
tj'''	2923	859	861	386			0.777
Tj	300	1000	800	300		2400	
Fj'''	1.024	1.164	0.929	0.777			

Iteration 4: -The fourth iteration can be done in tabular form also.

	I	II	II	IV	ti''''	Ti	Fi''''
I		140	125	33	298	300	1.0067
II	140		582	169	891	1000	1.1233
III	125	582		151	858	800	0.9324
IV	33	169	151		353	300	0.5576

tj''''	298	891	858	353			0.8498
Tj	300	1000	800	300		2400	
Fj''''	1.0067	1.1233	0.9324	0.8498			

Iteration 5: -The fifth iteration can be done in tabular form also.

	I	**II**	**II**	**IV**	**ti'''''**	**Ti**	**Fi'''''**
I		149	121	31	301	300	0.99
II	149		599	166	914	1000	1.09
III	121	599		134	854	800	0.93677
IV	31	166	134		331	300	0.906
tj'''''	301	914	854	331			
Tj	300	1000	800	300		2400	
Fj'''''	0.99	1.09	0.93677	0.906			

Since the results obtained from the two successive iterations give approximately equal growth factors, I can stop the iteration.

The disadvantages of this model are:

1.The factors do not have real significance.

2.Large number of iterations is required.

3. Detroit Model: -

This method is an improved version of the average growth factor method and takes into account the growth facor for the zones and average growth factor for the entire study area.

$$T_{ij} = \frac{t_{ij} * F_i F_j}{F}$$

where Fi =Ti/ti and Fj = Tj/tj and F= Total Tij/Total tij

Iteration 1: -F1 = 2400/1050 = **2.2857**

	I	**II**	**III**	**IV**	**ti'**	**Ti**	**Fi'**
I		131	131	33	295	300	1.017
II	131		525	131	787	1000	1.27
III	131	525		175	831	800	0.9627
IV	33	131	175		339	300	0.885
tj'	295	787	831	339	2252		
Tj	300	1000	800	300		2400	
Fj'	1.017	1.27	0.9627	0.885			

Iteration 2: -F2=2400/2252=**1.066**

	I	**II**	**II**	**IV**	**ti''**	**Ti**	**Fi''**
I		159	120	28	307	300	0.972
II	159		602	138	899	1000	1.1124
III	120	602		140	862	800	0.925
IV	28	138	140		306	300	0.9804
tj''	307	899	862	306	2374		
Tj	300	1000	800	300		2400	
Fj''	0.972	1.1124	0.925	0.9804			

Iteration 3: -F3=2400/2374=**1.010952**

	I	**II**	**III**	**IV**	**ti'''**	**Ti**	**Fi'''**
I		171	108	26	305	300	0.9836
II	171		615	149	935	1000	1.0695
III	108	615		126	849	800	0.9423
IV	26	149	126		301	300	0.9967
tj'''	305	935	849	301	2390		
Tj	300	1000	800	300		2400	
Fj'''	0.9836	1.0695	0.9423	0.9967			

Iteration 4: -F4=2400/2390=**1.0042**

	I	**II**	**III**	**IV**	**ti''''**	**Ti**	**Fi''''**
I		179	100	25	304	300	0.9868
II	179		617	158	954	1000	1.0452
III	100	617		118	835	800	0.9581
IV	25	158	118		301	300	0.9967
tj''''	304	954	835	301	2394		
Tj	300	1000	800	300		2400	
Fj''''	0.9868	1.0452	0.9581	0.9967			

Iteration 5: -F5=2400/2394=**1.0025**

	I	**II**	**III**	**IV**	**ti'''''**	**Ti**	**Fi'''''**
I		185	94	25	304	300	0.9868

II	185		618	165	968	1000	1.03305
III	94	618		112	824	800	0.9709
IV	24	165	112		302	300	0.9934
tj'''''	304	968	824	302	2398		
Tj	300	1000	800	300		2400	
Fj'''''	0.9868	1.03305	0.9709	0.9934			

since the ratio is approximately equal to 1, I can stop the iteration.

4. Fratar Method

The total trips emanating from a zone are distributed to the interzonal movements and according to the relative attraction of each movement, locational factors for each zone are calculated. Then

$$T_{ij}=\frac{t_{ij}*F_i*F_j(L_i+L_j)}{2}$$

The location factor values are computed below for the first iteration:

L1= 100 / 25*1+50*2+25*4 **0.444**

L2= 250 / 25*3+150*2+75*1 **0.556**

L3= 400 / 150*4+50*3+200*1 **0.421**

L4= 300 / 25*3+75*4+200*2 **0.387**

Iteration 1: -

	I	**II**	**II**	**IV**	**ti'**	**Ti**	**Fi'**	**Li'**
I		150	130	36	316	300	0.949	1.018
II	150		586	161	897	1000	1.1149	1.14
III	130	586		186	904	800	0.8849	0.9792
IV	36	161	186		385	300	0.7792	1.0131
tj'	316	897	904	385	2502			
Tj	300	1000	800	300		2400		
Fj'	0.949	1.1149	0.8849	0.7792				
Lj'	1.018	1.14	0.9792	1.0131				

Iteration 2: -The values in the table above can be used for this iteration.

	I	**II**	**II**	**IV**	**ti''**	**Ti**	**Fi''**	**Li''**

I		171	109	27	307	300	0.9772	0.9829
II	171		612	150	933	1000	1.0718	1.048
III	109	612		129	850	800	0.9411	0.9562
IV	27	150	129		306	300	0.9804	0.9917
tj''	307	933	850	306	2396			
Tj	300	1000	800	300		2400		
Fj''	0.9772	1.0718	0.9411	0.9804				
Lj''	0.9829	1.048	0.9562	0.9917				

Iteration 3: -The values in the table above can be used for this iteration.

	I	**II**	**II**	**IV**	**ti'''**	**Ti**	**Fi'''**	**Li'''**
I		182	97	25	304	300	0.9868	0.9893
II	182		619	161	962	1000	1.0395	1.0292
III	97	619		116	832	800	0.9411	0.9737
IV	25	161	116		302	300	0.9934	0.9948
tj'''	304	962	832	302	2400			
Tj	300	1000	800	300		2400		
Fj'''	0.9868	1.0395	0.9615	0.9934				
Lj'''	0.9893	1.0292	0.9737	0.9948				

The main drawbacks for this method are:

1. It is tedious for even moderate sized problems
2. It does not take into account the effect of changes in accessibility of the study area.

5. Furness Method: -

This method estimates the future traffic originating and terminating at each zone and hence yields the origin growth factor and destination growth factors for each zone. The traffic movements are made to agree alternatively.

Tij=tij*Ti/Total Tj and then Tij' = Tij*Ti/Total Tj' and Tij"=Tij*Ti/Total Tj"

Iteration 1: -Multiplying by the origin growth factors

	I	**II**	**II**	**IV**	**ti**	**Ti**
I		75	150	75	300	300
II	100		600	300	1000	1000
III	100	300		400	800	800
IV	25	75	200		300	300
tj'	225	450	950	775	2400	

Tj	300	1000	800	300		2400
Fj'	1.333	2.222	0.8421	0.387 1		

Iteration 2: -Multiplying by the destination growth factors

	I	**II**	**II**	**IV**	**ti''**	**Ti**	**Fi''**
I		167	126	29	322	300	0.9317
II	133		506	116	755	1000	1.3245
III	133	667		155	955	800	0.8377
IV	34	166	168		368	300	0.5152
tj''	300	1000	800	300	2400		
Tj	300	1000	800	300		2400	

Iteration 3: -Multiplying by the origin growth factors

	I	**II**	**II**	**IV**	**ti'''**	**Ti**
I		156	117	27	300	300
II	176		670	154	1000	1000
III	111	559		130	800	800
IV	28	135	137		300	300
tj'''	315	850	924	311	2400	
Tj	300	1000	800	300		2400
Fj'''	0.9524	1.1765	0.866	0.964 6		

Iteration 4: -Multiplying by the destination growth factors

	I	**II**	**II**	**IV**	**ti''''**	**Ti**	**Fi''''**
I		183	101	26	310	300	0.9677
II	168		580	149	897	1000	1.115
III	106	858		125	889	800	0.899
IV	26	158	119		304	300	0.9868
tj''''	300	1000	800	300	2400		
Tj	300	1000	800	300		2400	

Iteration 5: -Multiplying by the origin growth factors

	I	**II**	**III**	**IV**	**ti'''''**	**Ti**
I		177	98	25	300	300
II	187		647	166	1000	1000
III	95	592		113	800	800

IV	26	157	117		300	300
tj'''''	308	926	862	304	2400	
Tj	300	1000	800	300		2400
Fj'''''	0.974	1.08	0.928	0.9868		

Successive iterations are done until growth factors approach unity.

6.Time Function Method: -

This method assumes that the trip distance is influenced by the journey times and row and column totals the trip ends.

	I	II	III	IV	Current Origin
I		25	50	25	100
II	25		150	75	250
III	50	150		200	400
IV	25	75	200		300
Current Destination	100	250	400	300	

	I	II	III	IV	Current Origin	Ultimate Origin
I		1	1	1	3	100
II	1		1	1	3	250
III	1	1		1	3	400
IV	1	1	1		3	300
Current Destination	3	3	3	3		
Ultimate Destination	100	250	400	300		

Successive iterations are performed by alternately matching with the ultimate origins and destinations and finding the adjustment factors for column and row totals respectively.

Iteration 1: -

	I	II	III	IV	Current Origin	Ultimate Origin
I		100	100	100	300	300
II	333		334	333	1000	1000
III	266	267		267	800	800
IV	100	100	100		300	300

Current Destination	699	467	534	700	2400	
Ultimate Destination	300	1000	800	300		2400
Adjustment Factor	0.629	2.141	1.498	0.4286		

Iteration 2: -

	I	II	III	IV	Current Origin	Ultimate Origin	Adjustment Factor
I		214	150	43	3	300	0.7371
II	143		500	143	3	1000	1.2722
III	114	572		114	3	800	1
IV	43	214	150		3	300	0.7371
Current Destination	300	1000	800	300	2400		
Ultimate Destination	300	1000	800	300		2400	

2.4.2 Synthetic Models

Gravity Model

The trip distribution models found most often in practice today are "gravity models," so named because of their basis in Newton's law.

The gravity model assumes that the trips produced at an origin and attracted to a destination are directly proportional to the total trip productions at the origin and the total attractions at the destination. The calibrating term or "friction factor" (F) represents the reluctance or impedance of persons to make trips of various duration or distances. The general friction factor indicates that as travel times increase, travelers are increasingly less likely to make trips of such lengths. Calibration of the gravity model involves adjusting the friction factor.

The socioeconomic adjustment factor is an adjustment factor for individual trip interchanges. An important consideration in developing the gravity model is "balancing" productions and attractions. Balancing means that the total productions and attractions for a study area are equal.

Standard form of gravity model

$$T_{ij} = \frac{A_j F_{ij} K_{ij}}{\sum_{allzones} A_x F_{ij} K_{ix}} x P_i$$

Where:

Tij=trips produced at I and attracted at j

Pi = total trip production at I

Aj = total trip attraction at j

F ij = a calibration term for interchange ij, (friction factor) or travel time factor (F ij =C/t_{ij}^{n})

C=calibration factor for the friction factor

Kij = a socioeconomic adjustment factor for interchange ij

I=origin zone

n = number of zones

Before the gravity model can be used for prediction of future travel demand, it must be calibrated. Calibration is accomplished by adjusting the various factors within the gravity model until the model can duplicate a known base year's trip distribution. For example, if you knew the trip distribution for the current year, you would adjust the gravity model so that it resulted in the same trip distribution as was measured for the current year.