2.1. Introduction

At the very beginning of the development of Transport Planning, for historical reasons, planning models were influenced by the construction engineers and architects where the very basic goal of urban transport was to provide accessibility to land. Most of the studies at those times were traffic oriented and purpose was to build travel corridors after assessing future traffic demand in the vicinity.

The conventional planning model, as it has been thought out in those years even until the recent times, is one, which is schematically outlined in the Fig. 2.1. The diagram illustrates that there are two major components in the planning model, namely (1) Travel Demand Forecasting, (2) Evaluation of Alternative Plans.

The conventional planning models of the above type are generally meant for long term planning for the urban transport facilities and thus a great amount of emphasis were put on future travel demands that would be generated during the planning horizon. This exercise is taken care in the Travel Demand Forecasting component.

2.2. Demand Models

The so called 'four-stage' travel demand forecasting...
Figure 2.1

models (viz. Trip Generation, Trip Distribution, Modal Split, Traffic Assignment) have been the most popular tools available to the planners for the purpose of estimating future modal demands on every link or corridor of the study area. Hutchinson compiled all the classical travel demand forecasting models in a most systematic way (4). Some of these may be discussed with important comments.

The demand based models usually have the basic structure

\[ p_i^q = \sum_j t_{ij}^q \quad \ldots \quad (1) \]

\[ a_j^q = \sum_i t_{ij}^q \quad \ldots \quad (2) \]

where

- \( p_i^q \) = number of trips produced in zone \( i \) by type \( q \) tripmakers
- \( a_j^q \) = number of trips, attracted to zone \( j \) by type \( q \) tripmakers.
- \( t_{ij}^q \) = number of trips produced in zone \( i \) and attracted at zone \( j \) by type \( q \) tripmakers.

The basic objective of the planners and researchers is to estimate a realistic horizon-year trip distribution matrix, in various ways by synthesizing \( t_{ij}^q \). Fratar growth factor model (1) was the first important development.

in the area, where the model looked like the following:

\[ t_{ij} = b \cdot f_i \cdot f_j \cdot \left( \frac{l_i + l_j}{2r} \right) \ldots (3) \]

where

- \( t_{ij} \) = number of vehicle trips between zones \( i \) and \( j \) in the horizon year.
- \( b \) = the same as above, but for base year.

- \( f_i \) = growth factor of zone \( i \), given by \( \frac{p_i^h}{p_i^b} \),

where \( p_i^b \) & \( p_i^h \) are populations of horizon & base years respectively.

- \( l_i \) = location factor, given by \( \frac{p_i}{\sum_j t_{ij}^b \cdot f_j} \)

the constraints of equations 1 and 2 are satisfied using iterative procedures. Major limitation of the Fratar Model is that the model is not considering the properties of transport networks. Also future \( t_{ij} \) will be simply an extrapolation of the present trip pattern. The Frater Model, however, proved useful for inter urban travel demands, rather than developing urban travel demands.

The Gravity Model is one of the widely used stochastic models, used in urban environments. The basic structure of the model is

\[ t_{ij} = \frac{a_i \cdot f_{ij}}{\sum_j a_j \cdot f_{ij}} \ldots (4) \]
\( f_{ij} \) is known as travel time factor function or friction factor.

The model in equation (4) will satisfy the constraint equation (1), but not necessarily constraint equation (2). In order to satisfy this equation, iterative procedures are performed.

Wilson (2) developed a spatial interaction model which is based on entropy maximization principle of information theory. According to Wilson a trip distribution of gravity model must satisfy the constraint equations (1) and (2) and also a third constraint given by

\[
\sum_i \sum_j t_{ij} z_{ij} = Z \quad \ldots \quad (5)
\]

where \( z_{ij} \) = generalized cost of travelling from zone \( i \) to zone \( j \)

\( Z \) = Total amount spent on travel in the region.

Wilson showed in such conditions, the most probable \( t_{ij} \) matrix is given by the following form of gravity model,

\[
t_{ij} = K_i K_j \pi_i \pi_j e^{\beta z_{ij}} \quad \ldots \quad (6)
\]

where

\[
K_i = \frac{1}{\sum_j k_j \pi_j e^{\beta z_{ij}}}
\]

\[
K_j = \frac{1}{\sum_i k_i \pi_i e^{\beta z_{ij}}}
\]

The above is one form of gravity model, with a negative exponential travel time factor.

The idea of Wilson was extended to develop an well structured mode-choice model of the following form:

\[
\sum_j \sum_m t_{ij}^{mq} = p_i^q \quad \ldots (7)
\]

\[
\sum_i \sum_q \sum_m t_{ij}^{mq} = a_j \quad \ldots (8)
\]

\[
\sum_i \sum_j \sum_m t_{ij}^{mq} z_{ij}^m = z_j^q \quad \ldots (9)
\]

Here \( m \) is an added dimension, representing each mode.

Using the above constraints, Wilson derived (4)

\[
t_{ij}^{mq} = k_{ij}^{q} k_j^{q} p_i^{q} a_j \exp (-\beta z_{ij}^m) \quad \ldots (10)
\]

where

\[
k_i^q = \frac{1}{\sum_j \sum_m k_j a_j \exp (-\beta z_{ij}^m)}
\]

and

\[
k_j^q = \frac{1}{\sum_i \sum_m k_i^m p_i^q \exp (-\beta z_{ij}^m)}
\]

The above equation (10) represents a set of gravity models. Here for each \( m-q \) category an exponential travel time factor is associated.
Apart from the above sets of models, a number of families of models have been developed by the transportation planners and researchers. Out of these, the Intervening opportunities Models and competing opportunities models are worth mentioning. The philosophy behind the intervening opportunities models as proposed by Stouffer (3), is that

$$t_{ij} \propto \frac{a_j}{\omega_j} \quad \ldots (11)$$

where $a_j = \text{total number of destination opportunities in zone } j$

$\omega_j = \text{number of intervening destination opportunities}$

Hutchinson (4) referred Schneinder, Golding and Davidson, who proposed extensions to the initial philosophy of Stouffer.

Competing opportunities Model, as proposed by Tomarzinis (5), has the following form,

$$t_{ij} = p_i (pra_j)(prs_j) \quad \ldots (12)$$

where $pra_j = \text{probability of attraction to zone } j$

$$= \frac{a_j}{\sum_{\chi=1}^{n} a_{\chi}}$$
prs_j = probability of trip-end allocation
satisfaction in zone j.

\[ \text{prs}_j = 1 - \frac{\sum_{x=m}^{n} a_x}{\sum_{x=1}^{m} a_x} \]

where
- \( x \) = any time band
- \( m \) = time-band into which zone \( j \) falls
- \( n \) = last time-band as measured from an origin zone \( i \)
- \( a_x \) = destination opportunities available in time band \( x \).

Most of the above models, as mentioned, are subject to proper calibration by using various statistical data regarding network structure, travel behaviours, volumes of population in each zone of study area, journey times, costs, etc.

A variety of these models have been applied to a number of cities and decisions were taken on the basis of these.

But unfortunately recently the models are being criticized

(3) Stouffer S.A., Intervening Opportunities - A theory relating Mobility and Distance, American Sociological Review, Vol 5, No. 6, 1940.


because of inefficiencies both in the structure of the models and in the data qualities. Atkins (6) made an elaborate study on the technical papers where these models have been reviewed. It has been observed that in many situations these models failed to perform well even in the Western countries. In many cases it was found that the demand forecast ended into high degree inaccuracy. Horowitz and Emslie (7) reported, "It was found that 1968 and 1972 forecasts tended to overestimate 1975 Average Daily Traffic (ADT) by 24 and 21 percent respectively". Other investigators (8,9) also commented in the same way, highlighting substantial errors in the model forecast. According to Mackinder and Evans (10), "Further analysis of data showed that an assumption of zero change from the base-year situation would not have produced markedly larger forecast errors."

While commenting on the structural deficiencies of the models, Supernak (11) reported that in order to increase the 'explanatory power' of the models, more and more complex

(6) Atkins S.T., Transportation Planning Models - what the papers say, Traffic Engineering and Control, September 1986
(8) Jones P.M., et-al, Understanding Travel Behaviour, Gower, 1983
and sophisticated models were produced. It was also found that many of the large number of these explanatory variables were more difficult to predict than the dependent variables.

The amount of data errors in these models were also very high. The valuable comments of Stopher (12) in this connection may be quoted, "..... data collection is one of the most seriously ignored areas of transportation planning. If one reviews past transportation study reports, there is rarely any mention of the data collection procedure used as the basis of the forecasting and plan development ......... it seems that transportation planners have assumed that the clients for transportation planning cannot understand the fact that sampling errors and other measurement errors will exist and such admission would compromise the acceptance of planning." It has been reported by Jones (3) that the differences have been found upto one hundred percent between home-based vehicle trips as collected from local surveys and those observed at external cordon points.


It may be pointed out that the data availability is extremely poor in the LDC. Also the kind of data one needs for the conventional demand models, would be very expensive to collect. There have been researches recently however, to make use of small quantum of data and hence making predictions for future demands. Willumsen (14) devised several techniques appropriate for the LDCs to estimate existing travel demands and make forecasts (15,16). Traffic Counts, instead of home based interviews, are no doubt valuable for the purpose. Contribution of McFadden (17) in the field of Logit models (in application of modal split) opened wider scope for mode choice models and hence for forecasts of modal demands (18,19, 20,21). Studies of Willumsen and others in the areas of choice models using small databases in cities of LDC, are remarkable.

There is also another aspect to be considered in the context of travel demands in LDC. Apart from the existing demand for transport, a large number of persons make walk trips even up to a distance of five kilometers, the reason

(12) Stopher P.R., Data Needs and Data Collection - state of the practice, Transportation Research Board Special Reports, 1983


being that they are too poor to spend on transport or the present facilities are not acceptable to them.

Banister et-al (22) proposed three categories of demand in this kind of environment:

1. Effective demand, which is the traditional use of demand and passengers are willing and able to pay.

2. Unmet demand, which is the demand that is not effective for either fare is not affordable, or the service is not acceptable or there is no service at all.

3. Unexpressed demand, which is at present not generated but with the introduction of some suitable service, a fraction of people may express their desire to travel.

In fact, all the above three types of demands are required to be considered while planning for developing countries. However, adoption of these classical models are too ambitious, some times even impossible.

Looking at the peculiarities in the characters of urban transport in the LDCs, one can visualise that "incremental improvement" is more desired than the long term expensive plans. Because of acute financial crisis, acute pressure of travel demand, inadequate utilisation of already existing resources and the fact that the

government is under extreme public pressure to bring out quick improvements, in most of the situations a 'short term development' is hard pressed. Thomson (13) felt the urge of 'immediate action' or 'short term improvement' programmes in the cities of LDC. He argued that it is not at all required to forecast for next year, which could be visualised soon and thus frequently the needs for demand forecast models are not felt.

The classical modal choice models are however, not effective in many situations for a number of reasons. In the behavioural mode choice models, the concept of 'generalised transport cost' or disutility of a trip is considered to be the sole influencing factor for modal preferences (23, 24). The traditional models of this kind treat each available mode as separate entity, and each takes a share of market in some type of inverse proportion to the generalised cost of travel by that mode. The main inadequacy of this model as has been highlighted by Bly (25) and Glaister (26) that the travellers decide which mode is best, prior to setting


out for the journey. As a matter of fact this kind of model is much useful in the environment where there are physically separated accesses of service offered by individual mode. For example, an environment providing a choice among car, bus and train would be a typical application for such model where entry points of car bus and train are physically different. But in a situation where a number of transport modes are available on the same access spot, an appreciable variation in cost may be developed depending on the supply environment and the costs will be dynamic in nature instead of static as they are in case of generalised cost models. If the differences in cost components are not appreciably high, the choice of passengers would depend largely on which type of mode is first to arrive and whether any room is available in it or not. This theory reflects that decision point is shifted away from the start of a journey to the point of access to the service. Based on such theory, Glaister constructed a simulation model and proved that in a mixed mode environment mini bus


(20) Sobel K.L., Travel Demand Forecasting with the Nested multinomial Logit Model, Transportation Research Record, 775, 1980


services could be profitable to the operators even if they ran at low occupancy and high fares. This is because the passengers with relatively high values of travel time would be at times willing to pay for their higher operating speed, and frequent availability.

The environments similar to above exist in many of the LDC cities where a number of public transport modes provide parallel services along the same corridor. The choice models need to be appropriately applied in such situations.

2.3. Evaluation Techniques

The analytical tools which have been adapted by the planners for evaluation of alternatives are mainly cost-benefit, cost effectiveness and also sometimes cost-utility. The monetary measures of investments and operating costs are compared with the future benefits to be derived out of the alternative plans and finally the alternative, which estimates the highest value of the benefit-cost ratio, is accepted according to the cost-benefit analysis. The process calls for comprehensive evaluation of the following (27):

1. Money cost of investment and operation
2. User benefits and costs (Other than outlays)


3. Social cost and benefits, capable of quantitative description.

4. Social cost and benefit which are amendable only to qualitative description and analysis.

There are, no doubt, difficulties in evaluating the above costs and frequently a large number of assumptions are made in order to ease the tasks of evaluation. Dickey and Wohl (28, 29) highlighted a number of pitfalls of the cost benefit analysis. Unequal alternatives, problems of risk and uncertainties, measurement of variables, discounting of benefits and costs, double-counting of benefits and costs, determination of who benefit, etc. are the examples.

The cost-effectiveness technique works on the philosophy that better decision will arise if clearer and more relevant data are supplied to the decision maker. Here no attempt is made to translate all the benefits and costs in common element such as the money. In the cost-effectiveness analysis the attributes of the alternatives, relevant to decision are divided into two groups, namely cost and the effectiveness, which is defined as the degree to which an alternate plan achieves its objectives (23). There is, in fact, no hard and fast decision rule, unlike that in the cost-

benefit approach, but the decision is left only in the hands of the decision maker, who becomes knowledgeable enough with the type of relevant information for all the alternatives and the choice process becomes simplified. Cantilly (30) expressed high opinion on the process of cost effectiveness in programming environmental improvements in public transportation. In Manchester Rapid Transit Study (31) the method of cost effectiveness was utilised in order to evaluate an optimal transit system out of four alternatives.

The concept of cost utility may be considered as a modified cost benefit process where benefits that could not be explicitly measured in money value, a proxy value is developed to measure system benefit or 'utility'. Churchman et-al (32) suggested this technique for determining relative values of system goals. In this process, it is possible to evaluate collective decision where a number of interest groups exist and they have influence on the decision. In the Traffic Signal System Study of Baltimore (33), a number of traffic signal

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system alternatives made use of this method. The different outcomes as generated by the alternatives (may be called objectives) are ranked according to importance by each group and values are assigned to the rankings. The internal scale value \( j \), multiplied by the weight of utility measure \( w \) produce a gross utility \( jw \) and the total utility value is given by

\[
U = \sum jw
\]

In this way the \( U \) value is estimated for each of the alternative plan, and the alternative with the highest \( U \) value is chosen for implementation.

In case of decisions in the LDC, it is, however, to be pointed out that the final decisions are more political than technical. The government who are mostly the implementing authority are under high public pressure and also pressures from different related quarters, while accepting a decision or a solution. The actual decision making thus involves a high quantum of subjective influences. The evaluating processes in such situations should

(31) Miller J. and Dean J., Practical Considerations of Rapid Transit - a summary of Manchester study, Journal of the Town Planning Institute, April 1968


(33) Traffic Signal System Study, Department of Transit and Traffic, City of Baltimore, Maryland, 1969

be mere open ended like the cost effectiveness in a modified way or the cost utility where opportunities are available for making multi-person decisions. Starkle (34) drew a more appropriate structure of the transportation planning process which is illustrated in Fig. 2.2. The structure demonstrates that the political process is an integral element, which is in fact the steering body of the whole system. In this context, Prof. Tomazinis made valuable comments (35). According to him, "... for many years the transportation planners were busy in developing an analytical structure for transportation planning, which was based on travel demand projection models and on balancing trip assignments to link capacitors. This type of technical transportation planning in no case resulted in any bold initiatives for man transit". The author appealed for "a sensitive mix between analytical methodology and policy planning. It is not really one vs the other because both are critically necessary in producing plans that are both pace setting and practical."

Lee (36) suggested that to accommodate more heterogeneous participants, the process must employ increasingly simpler methodologies. He also suggested that to accommodate the political process in its various forms,


research must focus on policy issues and researchers must become more accessible to the users.¹

Figure 2.2

Structure of Transport Models

1. According to Lee, Communication is a key ingredient. Following the Lee's comments, Goldberg (37) suggested four groups of information processors, which may be integral part of planning process. These are Models, Modelers, Muddlers and Masses, as he named them. The Models are conceptual constructs which provide simulated policy impact as output. Modelers are the technically trained personnel, who design, debug, calibrate and run the models. The Modeler receives information inputs from the clients, viz. politicians, operators, citizens etc. and reacts accordingly. The Muddlers are the bureaucrats, politicians who receive information both from the models and the modelers.
2.4. **Important Observations**

The discussions took place in this chapter, mainly reflect the irrelevance of the available planning models in the application in LDC cities. The observations one can make from these are the following:

1. Until recently the models were frequently very complex, costly and most of the time lacked flexibility.

2. Due to high complexities and sophistications the models became often useless as often data generation was not feasible. It may be pointed out that in the LDC, data generation is even more difficult, expensive and sometimes impossible.

3. The complexities of the models make them difficult to be visualised by the interest groups who are affected by the plan such as politicians, citizens, etc. The result is that they are not happy but rather suspicious. It is not surprising that the potential users are discouraged at the outset from using tools which they cannot understand.

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related to the simulated effects of contemplated policies. The Masses are the society for whom the planning and policy making is done. The masses provide the essential political context within which all this information generation and processing takes place.

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4. Lack of provisions for policy inputs also made the models unacceptable to the decision makers. It is worthy to mention that in the LDC most of the public sector decisions are influenced by politician and/or other interest groups. Hence the present models are likely to have little interest in making use of them in such countries.

5. The socio-economic and political environment of any LDC is much prone to uncertainties of various nature. The structural instabilities of the cities are such that there is hardly any scope for assessment of future condition which is not so near. Thus the concepts of long term forecast, planning, etc. are just too ambitious in these countries.

6. The existing models are highly capital intensive and have been developed mainly for justification of heavy investments. The nature of problems are different in LDCs. Here concentration is required more on how to improve the existing system without much upgradation of hardware i.e., by restricting within the existing set of transport infrastructure.

7. Frequently the requirements of the elected governments are to produce quick results, to be presented to the public within their electoral term. In the traditional planning process, there is hardly any scope for meeting such immediate requirements.
2.5. **Conclusion**

On considering the discussions above, it may be concluded, the planning models that would be applied to the cities of LDC, should likely to have the following characteristics:

1. Low cost and short term.
2. Plans should aim at more quick tangible benefits.
3. Smaller, simpler and less ambitious qualities.
4. Flexible with provisions for wide sensitivity analysis.
5. Low-capital improvement models, rather than high investment installation models.
6. Special purpose models, appropriate to take care of specific problems, i.e., more of a problem solving type than of an intensive planning type.
7. Provisions for participation of different interest groups at various levels.
8. Interactive and graphic capabilities for better understanding and conversing with the models.