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A GUIDE TO TRANSPORT ECONOMICS

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INTRODUCTION

Economics is a science that helps to solve the basic problems related to optimal utilization of scare resource (in relation to demand upon these resources) which has most often the possibility of different uses. In essence, the principles of economics are one and the same where-ever there exist the question of scarcity of resources. It is, therefore, important to understand from the very beginning that transport economics is not distinct from other branches of economics. However, the peculiar characteristics of a sector has increasingly necessitated to discuss the economic problems and issues separately which is then designated as a separate branch of economics. Quite obviously, transport sector is a productive economic sector where the scarce resources can be utilized in the best interest of the owner of that resources. At macro level transport sector has historically played the opening role in the growth of economy. At micro level each individual project could be analysed as independent economic unit and justified on its own merits.

In order to increase the understanding of economic-rationale working in the transport sector, an effort has been made to discuss different issues in most simple way but also not ignoring the essential technical terms (may probably be understood only who have some basic understandings of economics and quantitatives techniques). Such a combination is expected to be useful both for economists and non-economists.

The present Guide is designed to describe the basic principle of transport economics. The economic decision analysis at micro level have been discussed in an other study, "A Guide of Project Appraisal, Monitoring and Evaluation (with special reference to Transport Sector) (NTRC-182)". The study has been, therefore, organized as following :-

In chapter-1 special characteristics of transport have been briefly described which, infact, provide the basis of a separate discipline in economics for transport sector. In chapter-2 the most important aspect of demand has been discussed. In view of complexities of demand estimation in transport sector, the modelling of demand (which is an essential ingredient of transport planning) has been further discussed in chapter-5. Chapter 3 and 4 have been devoted to supply side of transport (i.e. cost of transport) and different pricing principles for the transport sector. In Chapter-6 the concept of transport policy has been discussed.

CHAPTER I

SPECIAL CHARACTERISTICS OF TRANSPORT

The starting point of economics as an independent discipline is the "scarcity of resources" and "alternative uses" of these resources in order to maximize the "benefits" from given "costs" or minimize the "cost" to achieve the given "objective". Transport economics in its essence is not distinct from other branches of economics and the basic principles of economics are totally relevant for transport sector as well. Transport sector identically has, therefore, to be justified on its own merits vis-a-vis other sectors of the economy and different components/ projects within the transport sector have to be under same constraints. Inspite of these similarities, however, following are peculiar characteristics of transport sector which distinguish it from other sectors :-

(a) The most important feature of transport is that transport is basically not demanded for the sake of transport. The demand for transport is always derived demand in pure economic terms, unless one uses transport only for "leisure". Transport is, therefore, treated as cost in production process (though it has the service output).

(b) The unit of transport is most often in "bulks" and thus the nature of "fixed cost" in transport sector is accordingly high. This feature has important implications for transport planning, pricing etc.

(c) An important feature of transport sector is that the same service could be provided by alternative modes but once a mode has been developed, its replacement by some other mode is very difficult. If, for example, a choice has been made between "rail" and "road", then the system has to be continued for quite a long time. The bulky nature of investment, (feature 'b' above) also makes it difficult to make frequent changes. A minimum level of demand, is most often, required to justify the investment.

(d) The mobile part of the transport system has quicker depreciation (ships and aircrafts are exception). The replacement due to change in technology is relatively slow against fixed structure where economies of scale is dominant. This means that generally there is a minimum practical size below which the provision of transport infrastructure is non-economical.

The characteristics described at (a) to (c) above have important influence over shaping the institutional arrangement for transport sector. The bulky nature of infrastructure with long gestation period cause lack of interest from private sector (particularly in developing countries where managerial capabilities and capital availability is lacking) to invest in such projects of transport sector. The public sector, therefore, has to take the responsibility. Besides, such large scale investment also tends to create monopolies and an effective regulatory frame-work for them has to be provided. The dominant service nature of transport sector (because of derived demand) also necessitate the government intervention (particularly at the early stage of development). However, there exists substantial flexibility in mobile part of the transport which along with potential scale-economies create the condition for competition.

CHAPTER - 2

DEMAND FOR TRANSPORT

2.1 DESIRE FOR MOVEMENT AND LOCATION

Few people travel for the sheer joy of travel despite some excitement in some kind of travel. The basic purpose of travel is most often to take advantage of social, employment, educational, recreational and many other opportunities. The regional specialization and the benefits of division of labour are made possible by transport. Thomson (1974) has given following seven reasons for transport :

a) The difference in physical features of earth necessitate either to move and collect goods in demand or these goods should be brought to the place where these are demanded.

b) Specialization, which is the backbone of modern industrial development, requires to collect the requisite inputs from different regions/sources.

c) The improvement in transport system helps to further extend the economies of scale and encourage high level production.

d) Transport is essentially required for defence and political integration of a country.

e) Transport is required to bring social harmony in the society. Without transport social relationships are restricted.

f) Transport has extended the cultural interaction beyond the boundaries.

g) Transport has helped (and is required) to keep separate the job and residential locations and has thus changed the life style.

It would be seen that some of the elements described above have an element of interaction where one creates demand for the other. For example the selection of residential location creates demand for a particular type of transport and equally the availability of transport, besides other factors, influences the location of residence. This phenomenon is of great importance in transport sector which is known as the link between land use and transport. This relationship is, in fact, in the centre of urban transport planning. However, much of the transport economics literature is based on the existing land-use and its demand for transport rather than the otherway round.

In case of urban land-use, different income groups behave differently keeping inview their income level. This behaviour is summarized below :

(i) Other things being given, poor people who cannot afford high transport fares and place a low priority on large sites, are willing to bid higher rents for inner areas location. If the fares are reduced substantially, this class tends to move away from the inner areas of the city.

(ii) The wealthy class, other things given, tends to move to big sites at the edge of the city till such time that transport is comfortable and easy.

(iii) The high level of business activity at centre of the city attracts the business class to the centre of the city.

The centre theme of points (i) to (iii) is that high transport cost activities, other things remaining the same, will lead to a choice near the business centre and low transport cost activities will take locations further away. This clearly suggests that transport has significant effect on the urban cities by changing the demand for site. A substantial reduction in transport cost will motivate the poor sections of the city to move away from the centre and vice versa.

2.2. THE DEMAND FOR TRANSPORT

The difference between desire and demand in economics is that whereas a desire could be without purchasing power the demand has to be accompanied by the purchasing power. The demand for transport in this respect is not different in essence from the demand for any other good or service. In other words all the factors (i.e. price, price of substitute and income) are equally relevant for transport. (Besides total demand for transport also depends upon population). Functionally the demand for transport can be presented as :

$$DT = f(Pt, Ps, Py) \quad [2.1]$$

Where

DT = Demand for transport.

Pt = Price of transport service.

Ps = Price of alternative mode of transport service.

Py = Level of income.

However, as noted earlier, despite such similarities the transport has its own peculiar features which, therefore, requires further refinements in estimating the demand for transport. For example 'price' is not simply the fare paid but should include all other costs associated with particular choice of transport service (of which time cost is most often the most important). Similarly as passenger may not simply like to have a trip between two points but his choice of route and mode of transport are also equally important in making the trip. These kind of complexities, in fact, make it difficult to precisely and accurately identify the factors which influence the demand for transport service. The element of income and price of alternative is relatively simple as far as the theoretical description of demand for transport is concerned. However, the pricing of transport is much more difficult keeping in view that demand for transport is derived demand. The modelling of demand has been, therefore, further explained in an independent chapter-5.

CHAPTER 3

TRANSPORT COST

Of two important pillars of economics (i.e. demand and supply), the demand has already been explained. According to the elementary economic theory, supply is a positive function of price. However, the actual level of transport offered also equally depends upon the costs involved. The costs associated with transport could be classified as :

- Direct Costs and
- Indirect or External Costs.

It may, however, be noted that this distinction is only for the purpose of exposition as it becomes increasingly difficult to segregate them when transportation users are made responsible to pay for the indirect effects of transport. Realizing this, each of these have been described separately in the following sections.

3.1. DIRECT COSTS

Direct costs are those costs which are borne by the supplying agency and are, most often, financial costs (e.g. the wages of labour, the interest on capital, the cost of fuel). It is rather special (though not unique) that actual person being transported has to contribute his own time inputs and, when private motor transport is involved, his personal energies, skills and expertise. The opportunity costs of such time and the utilization of required skills will, therefore, directly be treated as cost of trips making. In other words the direct costs are infact the perceived costs or reaction costs what influence the supply of transport service. However, the shape of the cost per unit is more or less similar as in case of other production units where the cost per unit initially declines after touching the minimum and again rises and thus making the U-shape.

Direct cost could be either fixed or variable, specific or joint and common.

3.1.1. FIXED AND VARIABLE COSTS

There are a number of ways in which direct-costs could be classified. Describing the costs as fixed and variable is quite useful to analyse different kinds of transport costs, although this distinction only is linked to time factor. In the long-run all costs are variable costs and the time long-run differ for different types of transport (e.g. the long-run of a sea-port is very different from that in the road haulage or the bus industry). In case of a project whose useful economic life extends over 30 to 50 years, it is very difficult to precisely define the 'cheapest' of providing the facility in the long-run. On the other hand, the long-run in the context of vehicle fleet is simple and also relatively simple to analyse. Inspite of such difficulties, it is always possible to describe some costs as fixed in the short-run, keeping inview their temporal, indivisibilities, which will give different meaning to short-run (as in case of long-run). The closing of a railway line is a classical case. The essential question in this case is to precisely define the component of fixed cost associated with this rail service. The life span of different components differ significantly from one another. Earth work cost has an unlimited life (above 50 years), the track and signalling cost has a life of upto 40 years, locomotive has a life of about 15 to 20 years etc. In other words, in a very short period, by closing the railway-line, the only savings will be in terms of fuel, labour and maintenance since all other components have already been purchased. This shows that a pragmatic judgement about making a distinction between fixed and variable costs is essential on the part of decision-maker. In the short-run, there are certainly some fixed costs and, therefore, the average cost falls until the capacity is fully utilized. In case of train, for example, the average cost falls steeply unless capacity is fully utilized. A second train, if demand is there (and other facilities are also available) be brought in operation keeping in view the U-shape of short-run average cost (though the U-shape is not precisely smooth U-shape). The long-run cost curves are normally be longental but if there is a case, where inefficiencies exist in the industry then the curve would be U-shaped.

The economies of scale are equally applicable in transport sector. But, the transport sector is a complete composite of different major components. An increase in the size of one operational unit, say train or ship, will require changes in other components. The shift over the years from small trucks to large trucks, small ships to large ships etc. would also require to bring changes in basic infrastructure.

The variable costs of the transport are generally dominated by labour and fuel items. Similarly the mobile part of the transport system is treated as marginal since change in infrastructure are over a longer horizon. Hence, also there is a significant difference in different modes of transport. For example, the per unit of aircraft operations are very high while in case of road haulages cost per vehicle are low. Besides, the type of operation undertaken also influences the variable costs. The vehicle operating costs differ at different speeds with given load.

Labour costs, although flexible, are usually much less variable than fuel costs. The permanent component of labour is associated with the maintenance of capital infrastructure of the transport sector.

3.1.2. SPECIFIC, JOINT AND COMMON COSTS

The cost could also be classified according to the groups of services produced. It involves allocating responsibility for costs to specific users or consignors. While fixed and variable costs classification poses the problem of relevant time (i.e. short-run, long-run and what short and long mean) the cost responsibility raises issues of the traceability of costs. While some costs are very specific and could easily be allocated, in other cases some kind of averages and their allocation have to be made (but still there are always several costs which are 'joint' or 'common' and it is quite difficult to precisely allocate to any user). A very simple but not satisfactory, approach is to treat all fixed costs as 'joint' or 'common costs' and variable as 'specific costs'. But variable costs are equally 'joint' in some cases (e.g. the fuel costs incurred in moving a train in one direction and bringing it back are joint to both movements) or common (e.g. the basic maintenance costs of retaining a freight and passenger rail link).

The important implication and point to be clearly understood is that 'joint costs' could escape only jointly and therefore, are by definition non-traceable. Such costs cause the problem of pricing the service on different directions if the costs running on different directions are different. For example movements of train (and also trucks/lorries) from Karachi to

Quetta is more expensive than Quetta to Karachi. In a perfect market under such conditions there will be a different equilibrium price for different directions. It is, in fact, the equilibrium price that justifies different numbers of volume of service. And in such cases the practical difficulty to offer different volume of service will necessitate to charge the volume upwards/downwards according to the economic forces. In simple words, if law of demand does not recover the total 'joint costs', the price has to be increased (and so the volume reduced) to recover the 'joint cost'. In case of excessive revenue, the effect would be opposite. The key point is, if difference in demand exists or there are differences in costs in different directions, then different prices have to be charged to bring equilibrium. In practice such pricing becomes too complicated and the allocation of common costs have to be carefully determined on case to case basis if government fixes the fares.

The formula of allocation of common/joint costs from top to bottom by Pakistan Railways is creating problem to determine the efficiency of individual lines. A proper and more realistic allocation of joint/common costs by Pakistan Railways, for example, requires to change its whole accounting system and shifting it bottom to top, which means the costs of independent lines will have to be recorded first and thus the joint/common costs would be estimated. This will help to clearly distinguish between efficient and poor lines.

3.2. INDIRECT COSTS

There are most often some kind of indirect or external costs and benefits associated with an economic activity. Such costs are of much importance in transport sector. Noise creation of aircraft flight, vibration and direct effect on those living near trunk routes, pollution of beaches because of maritime transport, etc. are some very common and well known indirect/external costs of transport sector. These are the costs imposed by the transport users on those who have not used the service. Some important indirect costs have been briefly described below.

3.2.1. The Costs of Noise

The disbenefit of intrusive noise is now recognized as one of the most important effect of transport improvements. In the case of airports, urban motorways and railway lines, it plays crucial role in the selection of location of these facilities. An explicit analysis of the "Cost of Noise" is thus quite important in investment appraisal of transport projects. Though, there is, no unique method to measure the noise because it differs in a variety of ways (e.g. in its type, loudness, frequency, duration, timing etc.) besides affecting different people differently, yet it is now established that noise nuisance depends upon both the intensity and the frequency of the noise. The decibel scale (dBA) and Noise Number Index (NNI) are usual techniques for measuring

The valuation of the costs of pollution is too difficult and vague even if they are fully anticipated. In fact the perception of atmospheric pollution itself is imperfect. Though attempts to measure air pollution level tend to measure the estimates of constituent chemical components of direct exhaust emission, yet it cannot be precisely valued that how changes in these constituent chemical components affect the vegetation and animal life in short-run and long-run. Despite these difficulties the atmospheric pollution is increasingly receiving more attention because of its more visible negative effects on health. However, it is still not possible to put a precise quantitative value on such cost. A simple solution, probably, is to put some extra cost against a project for its extra consumption of energy which could be measured easily.

CHAPTER 4

PRICING IN TRANSPORT

4.1. ALTERNATIVE PRICING STRATEGIES

Pricing policy, particularly as it pertains to public facilities, can be established with many purposes in mind e.g.

i) Proper allocation of resources by signaling effective demand.

ii) Provide revenue for operating and maintenance and financing facility or help in the rational allocation of capital among competing projects (modes in transport system).

Prices set out in this manner (in transport also) often affect savings and investment rates within a society and the rate at which certain kinds of economic resources are brought into a market economy, domestic or international. If the objective is redistribution of income (e.g. school children, farmers living in remote areas or disabled) the pricing objectives may be independent of growth objectives. Normally, redistribution goals through transport policy are closely tied to such goals as promoting the development of underdeveloped regions or sectors of the economy; maintaining status-quo and financing losses in certain kinds of unprofitable "social services" provided by transport system. However, the major constraint on transport pricing policy is to generate enough revenue to meet the total cost. In general the most fundamental difference between alternative pricing strategies for transport, probably, is the degree to which a particular price is demand (or profit) oriented as opposed to cost oriented, although the distinction is not always clear cut.

4.2. PRICE PRACTICES, DISCRIMINATION AND AVERAGE COST PRICING

Price discrimination in transport sector is quite common. Following are different kinds of price discrimination practices :

a) Cyclical or recurrent price discrimination (time).

b) Interpersonal price discrimination (at one time).

c) Intertemporal or secular discrimination.

Most often price discrimination is done to maximise revenue (or profit) by equating marginal cost to marginal revenue, for different classes of users under monopolistic price. The effect of price discrimination is of fundamental nature in influencing the resource allocation. In USA rail charges relatively low price for commodities with elastic demand. (The demand elasticities and thus the marginal revenue, are generally assumed to be roughly inverse to the value of the product or service being rendered). Similarly long distance fare is different as compared to short distance and those who use transport frequently are charged at lower rate as against occasional users.

4.3. AVERAGE COST PRICING

Average cost pricing in application has differed somewhat in definitions. Normally, the relevant costs are defined as those of operating and amortizing a facility while output is some measure of the use of that facility. In the United States the federal government highway programme uses a price based on the cost of constructing new facilities and the output is taken as the use of all highways, old and new. There is also considerable disagreement as to the proper measure of output. Ton-miles, vehicle miles, and axle-ton miles have all been recommended. In practice the usual measures have been gallons of fuel and pounds of rubber consumed since these are easier units on which to administer an excise tax. In developing countries like Pakistan even these kinds of measurements are difficult. However, the excise duty on fuel (or fixing price of fuel if prices are controlled) in a way is linked to the fuel consumption, though it is not based on the cost of facility.

4.4. MARGINAL COST PRICING

Application of marginal price in transportation is based on the conventional economic justification to improve the use of resources. Under strict marginal cost pricing, an investment must be undertaken if the total revenue derived from the streams of output added and sold throughout the year at the variously prevailing (short-run) marginal cost prices, exceeds the cost for the year of using the (i) additional capacity; (ii) the cost of capital (interest and true depreciation) and (iii) variable costs incurred, throughout the year in utilization. Marginal prices faces a number of administrative and practical problems and thus difficult to practice particularly in transport sector. Application of short-run marginal cost pricing principles has been advocated for transport in circumstances where congestions create a divergence between private costs and the marginal social costs of using the facility. Profit could be realized by such pricing like quasi-rent where the demand exceeds the supply in short-run. Whether marginal cost pricing would result in a profit or loss in long-run equilibrium, would depend on whether the additional units of capacity were subject to increasing, decreasing or constant returns to scale. Specifically, only in the case of constant to scale with the marginal cost pricing scheme yield revenues exactly equal to those required to finance the equilibrium level of plant or capacity.

The conventional average rather than marginal cost pricing the facility would always be just self-sufficient. Which kind of pricing is superior is an old problem, discussed in the economics and transportation literature.

Another kind of marginal cost pricing is to set tariffs even if the facility is not at an equilibrium capacity, at a level equal to what is needed to cover the incremental cost of the last additional unit of capacity needed to achieve equilibrium. Long-run equilibrium marginal cost pricing of this type assumes that increments of capacity should be made available as long as people are willing to pay the incremental cost of supplying them. This rule which implies stable prices overtime is to be contrasted with the more strictly conventional varying cost and continuously changing the price according to changes in marginal cost over time. In general, the marginal cost pricing criterion for transport service is theoretically sound only, if all other services and other prices in the other sectors of the economy are also selling output at marginal costs. Applying marginal cost principles in transport, while other sectors pursue other types of pricing policies, might induce distortions and inefficiencies. In fact, systematic deviations from marginal cost pricing will usually be required for optimal resource allocation because of the need for the economy in aggregate to balance the deficits and surpluses of individual activities.

4.5 PRICING BASED ON USER-COST ESTIMATES

An extension of the long-run marginal cost approach in transport pricing is to separate facility costs into categories associated with incremental additions needed to serve different classes of users. Charges equal (as in average cost pricing) to the quotient of these categories divided by the units attributable to each category are then set. This is the unit of analysis is the household. The forecasting exercise will seek to estimate how many trips the member of the household will make to work, school, place of recreation, retailing establishments, and so forth. More or less in similar fashion, with a little modification, the trip demand of business firms or other basic behavioral units are estimated. In essence trip generation provides a picture of the origins and destinations of different trips and travel demands but not of the flows or interchanges between different points within the system. A typical simple estimating equation for trips originating in a residential zone could be :

$$T_i = a + bP_i + cY_i \qquad [5.1]$$

Where :

T_i = Number of daily trips produced in zone 'i'

P_i = resident population of zone 'i'

Y_i = average income of people in zone 'i'

a, b & c = empirically derived parameters.

In general, trips for household are positively related to household size, household income, and number of vehicles owned. The density of development is a variable with which it is negatively related. Subject to availability of information, equation 5.1 can be accordingly modified and empirically estimated. However, for developing countries like Pakistan the collection of information to capture the effect of all the important explanatory variables of trip generation is a difficult task and need intensive basic research studies. In fact in absence of such basic information, it is not possible to plan and organize transport sector on modern lines. The complexities involved in the ultimate use of this data essentially require the use of appropriate computer software (e.g. TRIPS).

5.2 ZONAL INTERCHANGE DISTRIBUTION

Zonal interchange models, (e.g. gravity or inverse impedance) provide a description or forecast of travel between areas. The gravity model is based on the premise that the volume of transport between two areas, 'i' and 'j' depends :

i) Directly on the number of tons of freight or passenger trips originating in 'i' needed at or destined for 'j' and is

ii) Inversely related to the distance, elapsed time, cost or some other measures of separation between 'i' and 'j':

Where :

$$X_{ij} = \frac{f\ (P_i\ P_j)}{d_{ij}} \qquad [5.2]$$

P = a measure of trip generation or activity (e.g. population).

d = distance or some representation of travel cost.

For purpose of linear estimation following form is usually chosen though it is not always true that distance variable or a suitable proxy can be represented linearly. Income is also often used as a measure of trip attraction.

Log Tij = loga + bPi - rdij [5.3]

Where

Tij = number of trips produced in zone 'i' and attracted to zone 'j'.

Pi = number of trips generated in zone 'i' or some important explanatory variables in zone 'i' (see trip generation equation 5.1).

dij = distance between zone 'i' and zone 'j' (Note that travel time/cost rather than actual distance may be and is usually used for 'd').

a,b, & r = empirically estimated parameters.

The equation [5.3] is too simple to capture the real situation, particularly when there are competing zones which attract trips generated in zone 'i'. In order to include this phenomenon, the gravity trip distribution equation (5.3) looks like as following :-

Log Tij = [LogPi + Aj - rdij] - [SIG TAn - rndin] [5.4]

Tij = As explained in equation [5.3]

Pi = -do-

dij = -do-

r = -do-

TAn = Other zones 1 ... n competing with 'j'

rin = j = distance between zone 'i' and competing zone 1 .....n

What equation [5.4] states in essence is that the share of the trips generated in zone 'i' (Pi), which go to zone 'j', is dependent upon both the attractiveness (Aj) of zone 'j' and the distance (or travel time/cost) from zone 'i' to zone 'j' relative to the features of all other attracting zones. Thus a new shopping centre in zone 'j' increases Aj and a road improvement reduces the time/cost between zones 'i' and 'j' decreases dij and of both of these increases the share of Pi captured by zone 'j'. A similar improvement in competing zones will reduce the share of zone 'j'.

To illustrate the concept behind the gravity model consider the situation in which we are allocating trips from residential zone 'i' to two commercial zones. We assume there are no other zones and that the relative attractiveness of the commercial zones is adequately represented by the number of square feet of commercial floor space in the zone. Zone A contains 1 million square feet of floor space and is 12 minutes from the residential zone. Zone B contains 400,000 square feet of floor space and is 7 minutes from the residential zone. There are a total of 1000 trips to be allocated between the two commercial zones. If we take the exponent 'r' as 2 (a reasonably close figure for the average of all trips), we get the following number of trips to zone A. (TiA).

$$TiA = 1{,}000 \times \frac{[1{,}000{,}000/(12)^2]}{[1{,}000{,}000/(12)^2] + [(400{,}000/(7)^2]} = 460 \qquad [5.5]$$

We obtain the number of trips to zone B by subtracting trips to zone A from 1000, as follows :

Trips to zone B = 1000 - 460 = 540 [5.6]

In practice, the gravity model is generally not a tool that can be used "off the self" but must be calibrated for the place in question using existing travel data. The actual value of r and the effective distances between places must be found. In a behavioural sense 1 mile of travel on an expressway may be shorter than 1 mile of travel on city streets, and 1 mile of travel on a commuter train may effectively be shorter than 1 mile of travel by bus or subway. A barrier such as a toll gate may, in effect, lengthen a route and so on. The urban network is, however, much more complex and that is why models for urban transport planning are often simultaneous determined.

5.3. MODAL CHOICE

Modal choice introduces major considerations. On the supply side of the transport market, i.e.

(1) assessment of the capacity;

(2) cost and

(3) performance of the existing or proposed transport system

the choice is a function of the network and performance conditions that exist at any given time and is difficult to be modelled. It could be done, however, as described below.

After zone-to-zone trips have been estimated the next step is to apportion those trips by mode. A variety of approaches are available. One approach is a disaggregative model. The model is a group of equations that estimate the probability of a randomly selected traveller or group of travellers choosing each mode. The equations are so structured that the sum of probabilities for all available modes necessarily adds to 1.

The data items that go into the probability-estimating equations include characteristics of both the mode and the trip maker. A commonly used personal characteristic is income. This variable is used because it is likely to affect the way in which the traveller evaluates the trade-off between time and money. For example, assume that commuter rail is fast and expensive, while bus is slow and relatively inexpensive. The wealthier the traveller, the more likely he or she is to decide that the time saving outweighs the monetary difference, and the greater the probability that he or she will choose commuter rail. The modal characteristics most commonly used, as might be expected, are cost and time. Different sets of equations may be used for estimating work and non-work trips. The equations are developed empirically from travel behaviour, generally in the area for which the study is being done.

As already mentioned the development of above kinds of equations require continuous and in-depth and basic research with substantial input of skilled manpower and money besides appropriate computer soft and hardware.

5.4. GENERALIZATIONS OF MODAL CHOICE

Following are some important generalizations of modal choice :-

(a) The crucial problems in passenger transport forecasting is to find out the valuation placed on different service characteristics by individuals making trips for different purposes and also identifying the extent to which the different modes of transportation meet the more important service characteristics at a reasonable cost.

(b) The major modes of domestic intercity passenger transport are bus, automobile, train and airplane. The cost of all kinds of modes can be specified in terms of say, passenger-mile basis, for the purposes of comparison (for airlines, seat available mile is also frequently used). The logistic cost should also be added because most of the time these costs significantly change the total cost of travel. The logistic costs are substantially different for different modes of transport. One of the most serious, yet least understood, economic and service disadvantage of passenger-train travel, is that its unit of efficient operation is relatively large. In USA, according to one estimate, it is uneconomical to schedule a train for less than 200 to 300 seats as compared to 50 to 60 per bus.

In addition the greater schedule flexibility (of both bus and private automobile) substantially reduces the probability that the traveller will lose time waiting for connections. Lack of schedule flexibility is one of the important explanations of the decline in intercity rail passenger service in USA. It may be noted that in USA the operating speed of bus, rail and other automobile modes is nearly the same.

(c) Making choice with regards to safety, most often the rail is ranked highest and the air least. People do react to the passenger fatality figures and that these diminish the attractiveness to travel by air, bus and automobile. An older traveller much fear of air than younger. In view of very high rate of accidents in Pakistan on highways and other roads the choice could be different. However, in absence of practical competition between rail, road and air in Pakistan it, probably, plays little role in selecting a particular mode.

d) There is little evidence in USA that the existing modes of transport will change in near future. Significant change in speed is unlikely to take place in near future. The transport characteristics in Pakistan, however, have under gone significant change over past two decades. Air transport has been the most growing mode of transport followed by small vehicles and large buses respectively. The share of railways in Pakistan has particularly declined. (See for further details NTRC-164 (1993)).

(e) The choice of travel mode is generally estimated in one of three ways :

(i) Based on the series of aggregate zonal characteristics and to the overall cost and quality of the transport service.

(ii) Use of 'diversion curve' enabling the proportion of trips using each mode to be calculated from a knowledge of passenger and route characteristics.

(iii) The third is based on regression analyses and attempts to obtain probability functions to predict the probability that a traveller will choose one of a number of competing modes.

A number of models have been developed on above three principles. The estimation of probability function has received much attention inview of some obvious shortcomings about estimation of 'i' and 'ii' empirically. However, in estimating such a function (iii above) a number of mathematical and computational complexities also emerge. The simplest form which can be easily estimated and has proved a good deal of efficiency in producing the probability of using a peculiar mode of transport is as following :

$$p = a(C2 - C1) + b(t2 - t1) + d \qquad [5.7]$$

Where :

p = the probability of using mode 1, car, if the traveller is car owner.

C2, C1	=	Costs of using modes 2 and 1 respectively.
t2, t1	=	Travel time using modes 2 and 1 respectively.
d	=	Probability of using mode 1, car, when 'Cs' and 'ts' are equal.

The accuracy of the model is considerably improved if the parameters 'a', 'b' and 'd' are expressed as function of income. The model can be further improved and made behavioural and mathematical consistent to reformulate in logistic form so as to keep p = 1.

5.5. ROUTE ASSIGNMENT

The resultant movement (described above) are assigned to the various available routes. In a simple network associated with most inter-urban traffic flows and with port traffic, it might be possible to carry out the assignment by inspection. The number of alternatives is usually limited and the choice between them may be obvious.

However, in more complicated networks, particularly those associated with urban traffic or traffic with in a densely populated rural areas, the alternatives are less clear and more rigorous method of assignment is usually required. The procedure of route assignment fall into three distinct phases : (a) the definition of an objective function; (b) the chóice of a method of assignment; and (c) the selection of preferred routes. Alternatively an economic demand model could also be applied.

5.5.1. OBJECTIVE FUNCTION

In case of a defined objective there are several choices of route. The time and cost are most often considered to be relevant, though costs and journey time are closely correlated. The length of the journey could be relevant if it affects time and/or cost and is used as a proxy for journey cost/time because it is much easier to calculate. The factors thus affecting the choice of route are usually defined in terms of travel times and distances or travel costs (defined to include the cost of travel time). The travel time combined with distance is the most frequent criterion used. It assumes that travellers :

(i) know in advance the travel times associated with each of several alternative routes; and

(ii) have a very simple objective function and attempt to minimize their total travel times.

5.5.2. METHOD OF ASSIGNMENT

Once an objective function has been defined it must be turned into a practical method of assignment. The simplest method assumes that each movement chooses a route which minimizes the above described function. This is the "All or Nothing" (AON) method and has the effect of assigning a great deal of traffic to some routes and none or very little, to alternative routes which may only differ by a marginal amount. Several methods are used to reduce the 'AON' effect. The most common is based on the use of 'assignment curve'. These compare the 'best' with the 'next best' alternative route and assign different proportions of traffic to each route on the basis of their respective travel time ratios; or of the travel time and cost or distance ratios. There are also several other methods of traffic assignment which avoid the simplistic assumption of 'AON' method. A more sophisticated, the capacity restraint assignment method, enables vehicle speeds to vary in relation to the actual traffic to each part of network. The traffic is first assigned to the minimum path but, as the assigned volume on each link approaches the 'practical capacity' of the link (where the link capacities are specified in advance) an iterative procedure lower the speed on the link (corresponding to the links' practical capacity) thereby making it less attractive to traffic. The model thus allows the flows and speeds to interact so that although vehicles still follow the least cost path, these least cost path changes in response to congestions causing the traffic to look for less congested routes elsewhere in the network.

5.5.3. SELECTION OF ROUTE

An alternate and simple way, as compared to two described above, is to assume that mode and route are selected simultaneously, which mean the route cost is perceived before a decision is taken for mode of transport.

5.5.4. ECONOMIC DEMAND MODELS

Economic Demand Models (EDM) tries to explain the behaviour of demand for travel in the light of conventional theory of consumer behaviour. The economic demand models are different from the usual traffic models in following three ways :

(a) According to EDM, the demand for travel depends explicitly on the price and quality of the service available. (The traffic models separate this into the independent activities of trip generation and distribution).

(b) The EDM deals with the entire process of trip generation, modal split, distribution and route assignment in one model. The effects of a change in price on the total volume of travel and its distribution between modes are thus represented in a single model.

(c) The EDM describes the determinants of travel demand in a way that corresponds to the theoretical (or other notions of about cause and effect.

The EDM model could be written as following :

N(i,j,i/P/o, Mo) = F(S(i/P/o), T(i,j,i/Po,Mo)} [5.8]

C((i,j,i/Po), T(i,j,i/Po Mx), C(i,j,i/Po Mx)} [5.9]

Where :

N(i,j, i/Po, Mo) = the number of round trips between 'i' and 'j' for purpose Po by mode Mo.

S(i/Po) = Vector of socio-economic characteristic relevant to purpose Po for living in zone 'C'.

S(j/Po) = vector of socio-economic and land use characteristics

		describing the level of activity relevant to purpose Po in destination zone 'j'.
T(i,j, i/Po Mo)	=	vector of travel time components for the round trip from 'i' to 'j' for purpose Po by mode Mo.
C(i,j, i/Po Mo)	=	vector of travel cost components for the round trip from 'i' to 'j' for purpose Po by mode Mo.
T(i,j,Po,Mx)	=	as above but alternative mode.
C(i,j, i/Po, Mx)	=	as above but alternative mode.

The underlying hypothesis for the equations [5.8] and [5.9] is that the number of round trips between any pair of zones for a given purpose by a specific mode, is simultaneously dependent on the : (i) number of people (or households) in the origin zone; (ii) on their socio-economic characteristics; (iii) on the level of economic activity, socio-economic and land use characteristics of the destination zone; and (iv) on the round trip travel times and costs of the subject mode as well as of any competing travel services.

The model described above is certainly not the only one and there is great deal of flexibility both in the mathematical form as well as detailed variable (e.g log model). The data requirements are more or less equal to traffic models and could be cross-sectional or historical.

5.6. DEMAND FOR FREIGHT TRANSPORT

Techniques for estimating freight transport demands are, in general, not well advanced. Freight demand models have been relatively crude and single equation fits to empirical data. As in case of passenger traffic, demand estimates based on industrial structure and land uses is very recent.

5.6.1. ESTIMATING FREIGHT TRAFFIC GENERATION

The first step in estimating freight traffic generation is to identify the main source of traffic. Survey of natural resource base, population and labour force will identify this source. In identifying those industries that will be the main users of the transport facilities, a base study must encompass following three broad elements :

(a) A determination of productive potential including both physical and human resources.

(b) An investigation of market potential.

(c) An assessment of entrepreneurial potential or the response of the local or regional economy to profit-making opportunities, including government and private investment plans.

The patterns of growth and input-output table should be used (if available) in determining the freight traffic demands. For the economy of a less developed country, which are not too complex, all other things being equal, fewer sectors will suffice for their descriptions. By contrast, estimating the regional or spatial dimension of input-output relationships, require more data and other information. New work on transport planning is almost always a serious practical problem. Regional data are often unavailable. Projection of future regional activity are perhaps even more difficult. The important thing is that the knowledge of the future transport system itself feedback on resource and industrial development. (In order to assess such effects needs a comprehensive macro economic model and its interaction with transport sector).

5.6.2. INTERZONAL FLOW MODEL

"Who sell to Whom" is the basic question to be answered. The "trade model" is the simplest zonal distribution of a good which is assumed to be in fixed proportion of the total amount of commodity consumed or produced in a region. Thus, the distribution of internal flows exit can be related by a trade co-efficient metric to regional consumption/output. The trade coefficient matrix is then used for forecasting.

CHAPTER 6

TRANSPORT POLICY

As highlighted in introduction transport economics is essentially required to deal with transport issues. Since different countries have different geo-economic and social conditions the transport policy has to be designed differently under the given resource constraints. Following are some important points (with brief references from transport sector of Pakistan) for formulating a good transport policy.

(1) The first important task is to clearly determine the overall requirements of transport (both passenger and freight) which are essentially required for the smooth functioning of the economy. As different economic and social variables grow over time a realistic forecast of different socio-economic variables have to be made and accordingly the transport infrastructure developed. Since transport infrastructure most often are of bulky nature with long life these forecasts are required for a sufficiently long period.

(2) The peculiar feature of transport that same service can be provided by different modes/ways requires extensive research and study before committing for a big transport project. For example linking north with south in Pakistan by an efficient and quick mode of transport could possibly be achieved by fast-

running trains or motor-way type roads. The selection of any one of these will have certainly financial and economic implications for the other. Construction of motorway between Lahore and Islamabad will change the total scenario of transport between these two areas. The future development of transport will also depend upon the infrastructure already available. The current and future economic activities for a quite long time could hardly, for example, justify the massive investment in railways once the motorway system is opted in Pakistan.

As in case of intra-modal the inter-modal choice of investment is also important. For example development of roads of different kinds to facilitate transport needs also detailed investigation.

(3) An important point for appropriate transport policy is not to rely on any one mode of transport. In market economies it tends to create monopolies and thus economic inefficiencies. Even in case of public infrastructure (funded and maintained from public exchequer) does not justify extra dependence on one mode of transport. A rational economic decision should be taken to develop a suitable modal-split for transport. All the avenues of transport should be evaluated and transport system developed on sound economic principles (rather than on simple technical grounds). The element of risk and uncertainty related to

different kinds of transport system and the efficiency of meeting different kinds of demands are crucial in such planning. Historically railways have played the role of opening in the process of economic growth/development followed by road transport.

In Pakistan the transport system, in terms of freight and passenger traffic, was almost equally distributed in the early seventies. There has been a gradual shift over the years and now about 85% of freight and passenger traffic is moving through roads. In order to create a balance model-split and healthy competition among different modes of transport, appropriate administrative and fiscal measure together with an appropriate internal (with in transport sector) adjustment programme is required. Such a change should be gradual under clearly defined short and long term objectives, supported by a continuous monitoring and evaluation research studies.

(4) Safe movement of goods and passengers always remain in the centre of a good transport policy. The risk of accidents can be reduced by continuously watching the changing pattern of transport and devising short-term, medium-term and long-term policies. In the short run the behaviour of those who operate, manage and administer the traffic is of utmost importance. Enforcement of traffic laws and regulations is, in fact, crucial

in transport safety. The identification and removal of 'black spots' are also equally important. Over a longer period, however, the design aspects of basic transport infrastructure and improvement in the safety standards of vehicles need more serious consideration. Shifting from single to double carriageway, adding more lanes to roads, dividing appropriately the burden of movement among different modes of transport could, for example, be managed only in medium and long term transport policy.

(5) Environmental and ecological effects of transport are of crucial importance. The air and noise pollution have received more attention than the long-term ecological problems. Even in this case measures are planned/taken when the problem reaches to an alarming level. In a sound transport policy the environmental problems should also be seen in distinct future and 'prevent' the problem rather than 'cure'. Ecological problems, though difficult to assess should also be at least clearly understood if some major transport infrastructure (e.g. motorway) are planned for implementation.

(6) Provision of transport by public or private sector has been an important policy matter. As a basic infrastructure, bulky nature of investment and long gestation period, state has almost every where and all the times played the pioneering role. The role of state is thus of utmost importance in providing the basic

the transport system of a country cannot be developed in an optimal way. Such research requires specialized trained manpower of different disciplines. The most important aspect of research in transport is linked with the dynamic properties of this sector. The transport issues and problems continuously change along with overall socio-economic change and with the expansion of transport sector in itself. Thus, research in transport has to be organized on a continuous basis and also brought to a level where its quality of research is of international standards to avoid external dependence.

Establishment of National Transport Research Centre (NTRC) in Pakistan (1974) was a significant step in this direction. Over a period of about three decades it has been developing appropriate trained manpower, which is one of the most difficult aspect as specialized manpower in transport (research) has a very limited chance of horizontal and vertical movement in career makings. An extensive research programme was also initiated in different fields of transport. However, the activities of the Centre could not be properly recognized and appreciated, 'probably', for the following two reasons :-

(i) It could not be properly understood that the development of a research institution of this sort is a very slow process and financially unremunerative. It therefore, requires continuous government support.

(ii) The potential benefits of research which is almost impossible to be quantified, are drastically under estimated at different forums and levels.

As a result of these two omissions the research activities of the Centre have significantly declined because of paucity of funds and lack of administrative support and appreciation besides poor co-ordinations with the potential users of the research studies done by the Centre.

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