EQUITY IN TRANSPORT PLANNING

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Submitted as part of

the requirements for the

Degree of Master of Philosophy.

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April, 1974.

Acknowledgements

I am extremely grateful for the help and encouragement the following have given me.

John Popper for giving valuable advice in the early stages of the work, for lending me some of his personal papers, and for comments made on the first draft.

Miller Allan and Doug McCallum for their comments and constructive criticism.

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INTRODUCTION

The original intention behind this study was to analyse who would receive the benefits and who would bear the costs of the Greater Glasgow Transport Study (GGTS) recommended plan (Tippetts, Abbet, McCarthey and Stratton 1967). This plan was recommended on the basis that it would minimise social costs (the combination of capital, maintenance and user costs), however no consideration was given to the distribution of costs and benefits resulting from the proposals.

Having studied the output from the GGTS transport model, it was found that it could not be disaggregated effectively, which would be required, if the distribution of costs and benefits was to be found. It was also considered that this type of study is of little use to the politicians who make the decisions on the transport plan. What would be of more use is a method which could be used in future evaluations.

It was then decided that an attempt should be made to design a new transport model and evaluation procedure in the light of existing deficiencies in transport studies, particularly the lack of equity considerations in the evaluation, using the GGTS as a case study. However the existing deficiencies threw up so many problems that further analysis of the GGTS and the production of a new model was not possible.

The main problem, of those encountered, is the use of the Kaldor-Hicks criterion[1], for the identification of an improvement, in cost-benefit analysis. Linked to this is the conceptual problem, that an infinite number of different distributions of costs and benefits can produce the same net benefit, so consideration of distribution can not be encompassed satisfactorily by cost-benefit analysis, which is based upon the maximisation of the single function of net benefit.

Other problems are due to the lack of consideration of the effect of the level of provision on 'demand', and the lack of consideration of different possible land use patterns. These and other problems if tackled would remove the practicability of comparing any improvements with the 'do-nothing' case upon which the calculation of costs is based. Another problem is due to the lack of explicitly stated objectives in transport planning. The use of cost-benefit analysis as the sole criterion upon which plans are chosen raises the objective of 'economic' efficiency to one of overriding importance.

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1. This criterion maintains that any change which produces a net gain is an improvement, even if some people suffer an uncompensated loss.

Consideration and evaluation of any other objectives in transport planning would remove cost-benefit analysis from its present dominant position. It would also pose serious problems of how to trade off one objective against another.

In the light of the problems encountered, a tentative new evaluation procedure is put forward. However it is still prone to many of the deficiencies of existing methods.

The contents are arranged to correspond to these deficiencies. In the first section an example is given of the methodologies presently used in transport planning and cost benefit analysis. In the second the reasons why equity should be considered in evaluation, and a method for doing so, are put forward. The third and fourth sections deal with many of the problems and deficiencies of present transport planning and cost-benefit analysis methodologies. The fifth section gives an account of how these and other problems affect the proposed method for considering equity.

A further problem that was encountered is that caused by the use of average values in numerical modelling. This problem is not confined to transport models. It is fully explained in the Appendix.

SECTION I

Chapter 1.

TRANSPORT STUDY METHODOLOGY

In a review of Land use - Transport studies in the U.K. Solesbury and Townsend (1970) identified two main influences in their development. The first was a growing political awareness of urban transport problems during the early to mid 1960's, which led the government to encourage the establishment of land use/transport studies[1]. The other was the development of early U.S. transport studies which produced packages of techniques for transport analysis. The first studies, which were started in the mid '60s, were for the large connurbations. During the late '60s the sub-regional studies produced, as one of their outputs, a transport plan for the area under study.

The general objective of transport studies has been to ensure that the transport system will cope adequately with future travel demand. To

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1. Solesburg and Townsend cite the issuing of Ministry of Transport & Ministry of Housing and Local Government (1965) which recommended comprehensive land used transport studies. The M.o.T. undertook to pay 50% of the cost of any studies made.

this end an analysis is made of the present transport system and travel pattern. From this analysis a model of the transport system is built up. The inputs to the model are those factors which are considered to determine the travel pattern which exists at present. These inputs are generally a description of the land use pattern, the socio-economic characteristics of the population and the transport system. The output from the model is a description of the resultant travel pattern. The model is initially built to represent present conditions. It is assumed that the relationships in the model will also hold in the future, so that given the changed inputs, the future travel pattern can be predicted.

Having built the model it is generally used to produce a description of the transport pattern for some date 20 to 30 yrs in the future, for the predicted change in land use and socio-economic conditions but for no change in the transport system. This will help in the analysis of where improvements could be made in the transport system for the target date. From this, a series of possible improvements are drawn up. The effect of these improvements is then predicted by re-running the model having first amended the transport network description to take account of the improvements. Predictions are produced for each set of improvements. A choice is then made between the possible sets of improvements, aided by cost benefit and operational analyses of each plan. Having decided on the improvements which are to be made, detailed designs of the new facilities must be produced and a decision made as to when, during the period between the present, and the design date, that they are to be built.

Of this process one of the most important elements is the transport model.

Transport Model

A transport model has as its input, a description of the transport systems, land use, and the socio-economic characteristics of the population, in the area under study. The model can be used to predict the resultant pattern of movement of people and goods.

The movement of people, which is the element upon which there has been most emphasis in transport studies, is assumed to be dependent upon people's needs and desires for such things as getting to work, to shops and services, to recreation and to suchlike, the disposition of housing and the places where these activities occur, and the availability of different transport modes, such as private car, bus or train. The relationships are expressed as equations which are generally calibrated from present day data which is obtained from a sample survey of households and traffic patterns. The household survey collects details on such things as family size, ages, income, car ownership, and, as part of the traffic survey, details of the journeys that every member of the family makes daily. The details of these journeys which are collected are, where a journey was to and from, what its purpose was, and what mode was used. The traffic survey also collects details of the flow of people and vehicles in the area of study.

For the purposes of modelling travel patterns the area is divided into small zones. All movements are assumed to start or finish at the centre of a zone. The transport systems are represented by networks of links which meet at nodes. Each zone is connected to nearby nodes by 'notional' links.

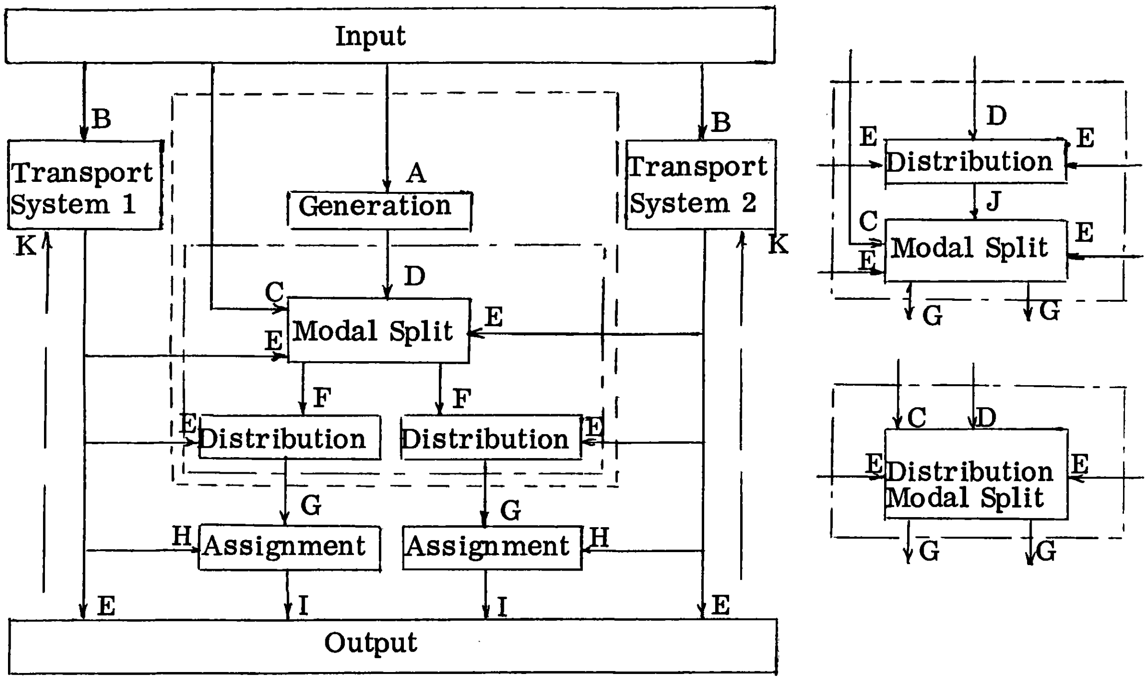
Having produced and calibrated the transport model it operates by; forecasting where individual trips will go from and to, i.e. their 'origin' and 'destination', known as 'trip generation'; forecasting for the set of trips starting at each origin, how many will go to each of the various destinations, known as 'trip distribution'; forecasting for each interzonal set of trips the proportion which will use each of the available modes, known as 'modal split'; and forecasting for each mode of transport the routes by which each set of interzonal trips will be made, known as 'trip assignment'. There are generally sub-models for different types of trip purpose, such as journey to work, to school, to shops, etc. These are kept separate until the trip assignment stage. Figure 1. gives a schematic representation of the stages involved.

Trip Generation. Most trips are usually found to be home based, that is either starting form or ending at the person's home. The home is considered the origin, and the other end the destination. The number of trip origins form a zone is related to the socio-economic characteristics of the population living in the zone. The number of trip destinations in any zone is related to the intensity of land use, such as the number of jobs or floor area of shops.

Trip Distribution. The distribution of trips between zones is usually determined by a gravity model, though some other models have been used.

Figure 1

Schematic Representation of a Transport Model.



(dashed box)	repeated for each purpose considered.
(dash-dot box)	alternative ordering for distribution and modal split.

A	Socio-economic and Land use projections.
B	Description of Transport System (and Value(s)[1] of time[2]).
C	Car ownership (by group).
D	Person trip ends, by purpose (and group).
E	Interzonal time, distance, cost or generalised cost.
F	Person trip ends by mode (purpose[3] and group).
G	Interzonal person trips by mode (purpose[3] and group).
H	Skim trees.
I	Flows on each link of each transport system.
J	Interzonal person trips.
K	Capacity restraint, iterative feed-back.
E and I	can be combined to produce total distance, time cost or generalised cost by mode.

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1. can be used if separate groups (perhaps by income) are used in behavioural modelling.

2. required if generalised cost is used.

3. between Distribution and Assignment all purposes are combined to give the total interzonal person trips.

The gravity model works on the basis that the number of trips between any two zones will be proportional to the number of trip origins from the one, and the number of trip destinations at the other, and inversely proportional to a function of distance between them. This function need not necessarily be of distance, it can be the interzonal travel time, interzonal travel cost or interzonal generalised cost[2], which is used in the trip assignment process. Corrections have to be applied to ensure that the total number of trips to each zone from all others is equal to the number of destinations for that zone and vice versa for origins.

Modal Split. The splitting of trips between the various transport systems available is sometimes carried out before, sometimes after and sometimes at the same time as the trip distribution stage. It is generally carried out by assigning all non-car owners to public transport[3], then splitting car owners trips between private and public transport. The split is made on the basis of some type of diversion curve which relates the proportions using each mode to the relative difference in accessibility by each mode, or of generalised cost, or some such function.

Assignment. The assignment of interzonal trips is usually made on the basis of an "all or nothing" assignment. That is all trips between two zones are assumed to go by the shortest route. (Other criteria can also be

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2. Generalised cost is a composite function of the time and monetary costs of a journey, which is used in an attempt to model behavioural patterns.

3. This is assuming that only two modes, private and public transport, are being considered.

used such as quickest, cheapest, lowest generalised cost, etc.). Any other type of assignment becomes computationally very complex. The routes used between zones are found by a programme which generates a tree of shortest routes to all other zones known as a "skim tree". This programme also compiles a note of which interzonal movements are carried on each link of the transport system. It is then a simple matter to find the volume of trips made on each link by summing all the interzonal trips which use that link.

Once the route loadings have been found it is generally necessary to check that each link can carry the indicated volume of trips. If it can not, a "capacity restraint" has to be applied so as to reduce the volume of traffic. This will involve in the case of roads, a decrease in the speed on the link so increasing the time of travel. This may remove some of the interzonal trips by making other routes quicker. If it does this will also have an effect on the distribution and modal split.

To use the transport model to predict future travel patterns, estimates have to be made of all the inputs to the model - the future land use pattern, the socio-economic characteristics of the people living in each zone and the transport systems.

The evaluation of transport plans has generally been on the basis of a cost-benefit analysis and an operational evaluation. The basis of the cost-benefit analysis is outlined in Chapter 2.

The operational analysis is a detailed examination of the volumes of movement on each link of the transport systems. For example on roads -

what congestion exists? are any roads so badly overloaded that stop-go conditions will exist on them for any significant time during the day? On public transport there is usually less necessity to apply capacity restraint procedures but there is a necessity to check that the assumed volumes of flow used to determine the frequency of service are approximated, to ensure that the operation is financially viable. It is not possible to reduce levels of service if volumes are too low without affecting the distribution, assignment, and especially the modal split.

Chapter 2.

COST - BENEFIT ANALYSIS

Cost-benefit analysis has been described as a "practical way of assessing the desirability of projects, where it is important to take a long view (in the sense of looking at repercussions in the future, as well as the nearer future) and a wide view (in the sense of allowing for side effects of many kinds on many persons, industries, regions, etc.) i.e. it implies the enumeration and evaluation of all the relevant costs and benefits" (Prest & Turvey 1965).

The development of cost-benefit analysis in the assessment of transport projects, in Britain, started in the late 1950s. Two early experimental studies were by Coburn, Beesley and Reynolds (1960) on the London-Birmingham Motorway and by Foster and Beesley (1963) on the Victoria line.

There are similarities between a private economic evaluation that might be made by a company before making a capital investment and a cost benefit analysis made by government before making a capital investment[1]. In both, estimates of the likely costs and benefits, how large they are, and when they will occur, are made. After discounting the future streams of costs and benefits to some measure such as their present value, a decision can be made as to how worthwhile the investment is. The important difference between a private economic evaluation and a cost-benefit analysis is that in the former only internal profit or loss is considered whereas in the latter all costs and benefits are considered, both internal and external. In cost-benefit analysis benefits are taken as the increase in consumers surplus which occur due to the change being considered.

In their survey of cost benefit analysis, Prest & Turvey (1965) list the main questions which have to be answered in an analysis as

"1. Which costs and which benefits are to be included?

2. How are they to be valued?

3. At what interest rate are they to be discounted?

4. What are the relevant constraints?"

Enumeration -

Ideally all costs and benefits to whomsoever they accrue should be considered in the analysis. Once the costs and benefits have been identified, their physical size must be calculated.

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1. Just as the company might make an evaluation if it were going to change only its mode of operation, so cost-benefit analysis can be used in more cases than that of capital investment.

Evaluation -

Having enumerated what benefits and costs exist they must be evaluated. This requires the placing of a value on diverse physical, and sometimes non-physical, quantities. The generally accepted values to use are those determined by the market. It is assumed that people act in a rational manner and that the present situation is a close approximation to the equilibrium position, to which the market is always moving. At equilibrium all commodities demanded are produced, all factors of production are in use and the marginal utility of all consumption is equal. In this position no one can be made better off without someone else being made worse off, since production is at a maximum, so, to make someone better off some of the produce would have to be shifted from one person to another, so making someone else worse off.

Provided the conditions prevailing in the "market" approximate those in the "pure market", market determined prices will approximate the marginal social value of all commodities and their use is justified because the use of any other would require individual subjective value judgments.

Discounting -

Once the costs and benefits have been enumerated and evaluated some process must be followed so that costs and benefits which accrue at different times in the future can be compared. The most widely used procedure is to discount the streams of costs and benefits to their present worth. To do this a time preference or discount rate must be chosen. It reflects the desirability of receiving a benefit this year rather than next year. Further consideration is given in Chapter 9 to the problems involved in the choice of a time preference rate.

Constraints -

There will be several types of constraint which may have to be taken into account in an analysis. There may be physical limitations on the size of possible benefits. There may be legal and/or administrative limitations on the size of specific costs or benefits, and to whom they may or may not accrue. There may also be a limited budget, in which case any project which exceeds the budget will not be allowed, no matter how large its benefits may be.

Enumeration and evaluation of transport costs and benefits -

In the cost-benefit analyses of transport projects,benefits have tended to be restricted to those accruing to transport users and operators. They have been regarded as the increase in consumer surplus produced by the change, that is the reduction in user and operator costs. More recently costs imposed on others have also been included.

User costs can be considered as the monetary costs of travel, time costs and accident risk. Operator costs for roads are those such as road maintenance, police, lighting and accidents. The other costs which are considered include noise, vibration, visual intrusion, etc. Any increases in these costs are usually considered as negative or dis-benefits.

Project Selection -

When there are several projects competing for a limited allocation of funds cost-benefit analysis can be used to make the choice of those with which to proceed. Provided there are no mutually exclusive projects, those which have the highest ratio of discounted benefits to discounted costs should be implemented first.

SECTION II

Chapter 3.

WHY EQUITY SHOULD BE CONSIDERED IN COST-BENEFIT ANALYSIS

Equity and Efficiency -

Any productive process can be considered in two separate lights, one, the quantity of production, the other who gets the benefits, or the "distribution". In economic analysis these are generally considered separately under the respective headings of efficiency and equity. Efficiency is concerned with quantity produced for a given input of resources, whereas equity is concerned with the fairness[1] of the resultant distribution of income or benefits.

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1. The usage of the word equity in economics is somewhat different from the dictionary definition.

"equity (ek'witi) (O.F. equite, L. æquitas - ta tem, from æquus, fair , n Justice, fairness; the application of principles of justice to correct the deficiencies of law ....."
(Cassell's New English Dictionary 1949)

In a paper on "Equity" Scitousky (1964) says:

"It is no accident that the English word equity comes from equus, Latin for equal. By equity people mean, if not equality, at least something that approximates it closely enough to satisfy them. The public is satisfied with something short of equality, partly, perhaps, because it is resigned to this being an imperfect world, and partly also because it recognizes the impracticability of perfect equality. The latter is unattainable as long as we need to provide economic incentive to produce the national product."

Here equity is taken to mean the fairness of the distribution of income or benefits, but the decision about what is fair must be made elsewhere.

Consideration of Equity in Economic Analyses -

Any analysis which considers the equity of a change must involve the comparison of the change in benefits (or income) received. If the benefits (or income) are evaluated in monetary terms, assumptions must be made as to the value (or more strictly the utility) each individual places upon the same monetary unit. In other words when considering equity, interpersonal utility comparisons must be made. However there is no objective way to make such comparisons.

Justifications for ignoring equity -

This lack of objectivity caused by the consideration of equity in economic analysis is usually overcome by ignoring equity and considering efficiency only. There have been several justifications of this approach.

1. The change in this distribution caused by any activity subject to analysis will be small, and the changes to individuals' incomes will be small and occur randomly. So when all activities are considered any loss to an individual will be offset by other gains.

2. If the distribution of income (or benefits) is unsatisfactory corrections will be made in the political field by changing the tax structure so as to alter the incidence of transfer payments.

3. The existing distribution of income is satisfactory. That is an income distribution which is accepted as being socially desirable will arise through the creation of a tax structure,

which involves transfer payments, through the political process. It can be argued that a progressive income tax will offset the decreasing marginal utility of income so that every unit of net income has the same utility.

Pareto Criterion for an Improvement -

The only unambiguous criterion for an improvement is that put forward to Pareto, namely that at least one person is made better off while no-one is made worse off. Any other criterion will involve the making of interpersonal comparisons. In the interests of simplicity and practicability simplifying assumptions are made.

Kaldor-Hicks Criterion -

In cost-benefit analysis the criterion for an improvement is that put forward by Kaldor and Hicks, namely that there is a net gain (i.e. the gainers could compensate the losers, whether or not they do actually compensate them). This criterion depends upon the assumptions that the marginal utility of money is constant and that the utility different people attach to money is comparable.

Pigovian Social Welfare function -

The ignoring of equity and the much simplified criterion for a change to be considered an improvement have led to the wide scale use of what Foster (1966) has called the "Pigovian social welfare function" in cost-benefit analysis. Foster defines a decision (or social welfare) function, SWF, as one which is logical, states (i) to whom the benefits accrue (ii) who bears the costs and (iii) the weights to be given to the various components of (i) and (ii). The "Pigovian SWF" is that where all (i) and (ii) are taken into account and (iii) the monetary values are all given equal weight.

However the reasoning which leads up to the adoption of the 'Pigovian Social Welfare Function' in cost benefit analysis is extremely tenuous.

Inadequacies of not making inter-personal utility comparisons -

The consequences of not making inter-personal utility comparisons "..... were pointed out in 1932 by Professor Robbins (1932). He maintained that if economics were to have the objectivity of a science, economists may not make inter-personal comparisons and may not, in their capacity as economists, argue for or against any policy or change of policy that would make some people better and others worse off than they were before. Considering that practically every economic change favours some and hurts others, Professor Robbins was, in effect, baring himself and his colleagues from any policy recommendations whatever".[2]

Inadequacies of ignoring equity -

The argument that any losses which result from a change are small and random is open to considerable doubt, they are just as likely to be large and cumulative. For example any redevelopment or road building in a city will probably tend to give most benefits to the richer suburban residents and most costs will be borne by the poorer inner city residents. This is due to two causes. Firstly the poorer sections of the community do not have the political power to ensure they do not suffer dis-benefits from redevelopment

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2. From a paper on "The State of Welfare Economics" (Scitovsky 1964 pp. 174-189).

or road construction. Secondly most of the building will take place in the central areas, and it will be the inner city residents who are disturbed the most.

The arguments that the existing income distribution is satisfactory or will be made satisfactory by the political process is also open to doubt since there is not a uniform distribution of political power. Those in an economically favourable position also tend to hold political power. They will be unlikely to agree to any change in distribution.

Inadequacies of the Kaldor-Hicks Criterion -

The Kaldor-Hicks criterion is unsatisfactory since whenever it is used the implicit assumption that money has the same utility for everyone, is made. This is an inter-personal utility comparison and, as such, it is a value judgment. In consequence every time the Kaldor-Hicks criterion is used an implicit value judgment is made.

Also, it is not self evident that there is an improvement if anyone is worse off, which is allowed by the Kaldor-Hicks criterion. However, even if this were overcome by stipulating that everyone who suffers a loss must be compensated, "the notion that .... any unfavourable effects on income distribution can be overcome by making some of the gains compensate some of the losers is rarely applicable in practice." (Prest and Turvey 1965).

Inadequacies of Pigovian income distribution -

The use of the Pigovian social welfare function depends upon the assumption that the resultant income distribution is satisfactory, but as Foster (1966) has pointed out "most writers on cost-benefit analysis have recognised that the income distribution that results from the use of the Pigovian function has no apriori validity, and that it is possible and sometimes politically desirable to modify the function so as to bias project selection in favour of some other income distribution".

Conclusion -

Equity has in the past been ignored in decision making processes which are based upon cost-benefit analysis, in an attempt to give objective advice, since considering equity requires that subjective inter-personal comparisons be made. However the arguments used for ignoring equity are based upon the implicit assumptions that utilities are comparable and that the Kaldor-Hicks criterion is 'acceptable' which are themselves subjective judgments. Consequently no 'objective' advice can be given, and any advice which is given will be better if equity is explicitly considered.

Chapter 4

HOW EQUITY MIGHT BE CONSIDERED

There have been several suggestions recently as to how equity considerations might be incorporated into cost-benefit analysis. Some of these suggestions such as that of Foster (1966) are applied within the framework of a single analysis whereas others such as that of McGuire and Garn (1969) are applied when cost-benefit analysis is being used to select projects from a large number of feasible projects when there is a limited budget.

Internal consideration of equity -

The consideration of equity within a single cost-benefit analysis can be handled in several ways. The analysis can be conducted as normal but extra constraints can be added, such as, the project is rejected if the benefits to a pre-defined group are smaller than some desired amount, or are smaller than those of another group. Another method would be to proceed as normal but detail how costs and benefits are borne by different sections of the community, and leave the decision as to whether it is acceptable to the decision maker.[1]

Before making his own suggestion Foster lists 3 ways in which income distribution can be incorporated in cost-benefit analysis,put forward by Marglin (in Maas et. al. 1962). These are (i) modify costs and benefits by weighting (workable if specific groups can be identified and if weights can be agreed upon). (ii) maximise net benefits of a favoured group (difficulties will arise if continued indefinitely without counting the cost of doing so). (iii) maximise the 'Pigovian' function subject to an income constraint. It is the first of these which Foster proposes in his "Democratic Strength of Preference Social Welfare Function".

Foster's function is one in which all costs and benefits are considered and their monetary values are weighted by the average income of the groups on which they fall. His aim is not to transfer cost-benefit analysis from economics to politics but to show (i) an affinity between the two types of decision process (ii) that political decisions can be made by using a decision function in a cost-benefit analysis framework and (iii) that there may be some 'social' costs and benefits which are more in line with this rather than the 'Pigovian' function.

There are four main problems which Foster lists;(i) to whom should costs and benefits be applied; the head of the family? if so how can different

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1. These two methods are suggested by Prest and Turvey (1965).

family sizes be coped with? and what mean income should be used as it varies over time and area? (ii) There are problems of reduced efficiency inherent in this function. "This is no more than to say that this decision function would have a redistributive effect" (Foster 1966) (iii) There are problems of expanding and compressing income elasticities - does it have the desired result? (iv) What income level should be used?

To these problems should be added a fifth. The function will give different results dependent upon how the population is divided into groups. It will tend to vary between a limiting value and the value produced by the 'Pigovian' function as the spread of the distribution of income within each group varies from the very narrow to that of the whole population.

External consideration of equity -

The recommendations of McGuire and Garn were developed "..... for consolidation of equity and efficiency criteria in the selection of regional development projects in the United States" (McGuire & Garn 1969 p.882). They list four important factors with which the federal decision maker is faced (i) More projects than resources available (ii) A wide variation in expected benefits (iii) A wide variation in need (iv) Projects from poor areas will usually have a lower benefit-cost ratio. In the light of these problems they list five decision functions which have been suggested. They are similar to those for dealing with single projects.

"1. Ignore questions of need and exhaust the budget on the most efficient projects.

2. Ignore efficiency and give the grant to those who need it.

3. Establish a minimum efficiency and select according to need; look at the outcome and re-evaluate the constraints.[2]

4. Establish a minimum level of need and select according to efficiency, look at the outcome and re-evaluate the constraints.[2]

5. Develop an explicit preference function between need and efficiency." (McGuire & Garn 1969 p.888).

It is the last of these five which they develop into a decision formula which incorporates both equity and efficiency. It gives the decision makers a guide as to the selection of projects from a large number which for a given level of overall efficiency will be most equitable. However this method of applying an external preference function would be difficult to apply in the context of a transport plan for a single area. In the function developed for the selection of regional development projects equity is incorporated by making the results from areas of greatest need more attractive. Cost-benefit analysis of transport plans, in which the costs and benefits for each plan under consideration fall upon people from the same area, is not amenable to this treatment. To apply an external weighting to the results from each analysis, the costs and benefits must fall upon different and identified populations.

2. Proposed by Marglin (1967) as an iterative procedure for balancing equity and efficiency in long range planning.

Conclusion -

Both of these methods, one applying an internal weighting and the other an external weighting, still do not cope with a fundamental problem. That is no uni-dimensional function, such as net benefit, weighted net benefit, or benefit-cost ratio, can adequately represent a distribution of costs and benefits, which is essentially a multi-dimensional function.

Chapter 5

AN ALTERNATIVE APPROACH

Unsuitability of Decision Function -

In an attempt to make 'rational' decisions, that is decisions which follow the 'synoptic ideal',[1] planning methodology has been developed along the lines of the "alternatives" approach. The method is, having ascertained the goals and objectives, to postulate alternative solutions which may achieve the goals and objectives. The alternatives are evaluated and the one which satisfies the goals and objectives best is chosen. This method, due to the limited number of alternatives tested, is very unlikely to find the 'best' plan, especially when the criteria for 'best' is expressed as a function which has to be maximised.

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1. The "Synoptic ideal" is that the decision maker
   1. has knowledge of unambiguous goals and objectives
   2. has a comprehensive knowledge of the situation
   3. identifies all relevant alternatives
   4. evaluates the consequences of all alternatives
   5. selects the alternative which most closely fits the goals and objectives.

Further difficulties arise if there is more than one objective which is to be maximised. Either, all but one of the objectives must be reduced to constraints, or a composite objective must be produced. There is a severe problem in formulating a single composite objective, it is; what weight should be given to each of the individual objectives? Often changing the weighting of the various objectives will alternative which is chosen.

This makes the procedure very unsuitable in a political process since the only part the politician plays in the procedure is the setting of the objectives and their weighting. If there is more than one politician it may not be possible to obtain a set of weightings which is acceptable to a majority let alone one which is acceptable to all.

Over and above the problem of finding an acceptable set of weightings is that of the politician not being able to comprehend the effects of different weighting systems. This is because the setting of weights is so far removed from the final result in the decision making process. However it is at this point at which the politician, and more particularly the public in the case of public participation, must act if any effect is to be made on the result, within the confines of this type of decision making process. If the public do not affect the decision this way, or even if they do, they are unlikely to accept the results of a decision which is made on the basis of a weighting system which is different from that which they would have chosen individually.

These problems of lack of involvement and of what weightings to use will also occur in cost-benefit analysis if the values of the costs and benefits are to be weighted on equity grounds. There is a fundamental problem of trying to reduce a description of the incidence of costs and benefits to a single value, since a single value can cover a multitude of possible distributions.

Testing a few alternatives is a poor way of finding the solution which maximises a given function. It is even worse when there are several objectives or considerations of the distribution of the function over the population are concerned.

An alternative approach -

The "alternatives" approach to decision making could be replaced by a "learning" or "iterative" approach. It would be more likely to find a closer approximation to the 'best' plan, especially when 'best' is expressed in terms of maximising a given function. The procedure involves, the formulation of a solution, the testing of the solution against the objectives, and then in the light of the results of the evaluation, the solution is improved. These stages of 'testing' and 'improvement' can be repeated as often as is considered desirable.

There is scope in this procedure for a greater involvement of the politicians and public, especially when multiple objectives or distribution are concerned. That is at the stages between testing, and plan modification.

At this point the politician or public can say in which areas the modifications should be made.

Proposed framework for identifying the distribution of costs and benefits -

This is a proposed method for identifying who bears the costs and who receives the benefits in the testing of a transport plan. The results would not be used to choose between plans but rather to indicate areas in which the plan should be modified. This would lead to an iterative process of producing the plan. It should be possible to devise a process whereby the effects of changes in the transport network can be analysed without having to re-run the entire transport model every time modifications are made.[2]

The basic framework for this type of analysis has been proposed elsewhere in unpublished papers by Michael Tyler and John Popper. The intention is to identify all groups which bear costs and receive benefits. Of prime importance will be the incidence of costs and benefits on the consumer. That is because it is in this sector that it will be most difficult to make transfer payments from net-gainers to net-losers, or to make the distribution of benefits as even as possible. Of course it is also important to consider the effect on other sectors such as on commerce and industry who use commercial vehicles, where benefits and costs do not directly affect the final consumer. It is necessary to consider them separately since it would be

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2. See Halder (1970) where a method of determining "..... the effect on the trip assignment of changing parts of the network" is outlined.

very difficult, if not impossible, to trace the benefits to commerce and industry through to the final consumer, as well as to its owners and to the government (from changes in tax revenue). It is of considerable importance that the effect which any changes will have on the transport operators should be taken into account. It has been pointed out, in Foster & Beesley (1965) that the level of benefits is affected by the level of fares, and by the level of tax revenues to the government.

A fundamental differentiation can be made between those costs and benefits due to differences in operation of the transport system,[3] which affect the users, the operators and the government, and all other costs and benefits. These 'other costs and benefits' are both those occuring when physical changes are made to the transport system,[4] and those which occur due to the operation of the transport system[5] other than those mentioned above. Secondary effects such as the benefit of an enlarged catchment area to a shop pose problems. There is both the danger of double counting and more importantly, they are extremely difficult to analyse and quantify.

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3. These costs and benefits are negative and positive reductions in costs and increases in revenues between the "do nothing" system and the system under test.

4. These include the capital cost which falls on the government and/or operators, and disturbance costs which fall on those whose housing is affected by construction, and those users of the pre-existing system who suffer delays.

5. Such as costs imposed due to noise and air pollution.

The first set of changes can be predicted directly from the transport model.[6] Person trip user costs can be evaluated for all trips originating in any zone. Since most trips are home based, it is possible to identify which households receive benefits so long as non-home based trips are considered separately.

Some of the public transport operators' costs are fixed, but are dependent on the scale of operation and some vary with the length and density of routes served. The public transport operators' revenues can be calculated by summing the product of the individual elements of the inter-zonal fare matrix, which can be produced from the inter-zonal distance matrix. (These matraces are created as part of the working of the transport model).[7]

The tax payed by private road users can be estimated by multiplying the number of interzonal private trips by the corresponding interzonal distances by the tax rate per mile and summing over all trips. This does not include the road fund tax payed on vehicles, but if the level of provision of roads is assumed not to affect car ownership, and since only differences in tax revenue are being considered, this does not matter.

The incidence of costs and benefits can be represented in Tabular form such as in Figure 2 based on a table in Tyler's Paper. The important part is the incidence of costs and benefits as they fall on persons living in

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6. The basic method is that proposed in Popper's paper.

7. All the user costs and benefits could be calculated without difficulty from data which is used within present transport models.

Figure 2. Framework for showing the incidence of costs and benefits.

Sectors to which benefits accrue	Users, area specific	Users, non area specific	Goods area specific	Operator(s)	Government	Social Benefit
Effect on Public Transport						
user benefits	+ 160	+ 20	O	O	O	+ 180
revenue	- 40	- 5	O	+ 45	O	O
operating cost	O	O	O	- 30	O	- 30
Effect on Road System						
(Private) user benefits	+ 190	+ 10	+ 80	O	O	+ 280
tax	- 10	+ 5	- 10	O	+ 15	O
accidents	+ 20	+ 5	O	O	+ 10	+ 35
Capital cost and maintenance cost	O	O	O	O	- 200	- 200
Total benefit	+ 320	+ 35	+ 70	+ 15	- 175	+ 265

All entries are made in terms of present value resource costs.

The "Social Benefit" of items such as the public transport operators "revenue", and "tax" will be zero since these are transfer payments.

The "Total benefit" is the effect the change under study has on each of the identified sectors.

specific areas. These can best be presented in map form, showing the level of costs and benefits per person for each zone. An example of how user benefits might be presented is given in figure 3.

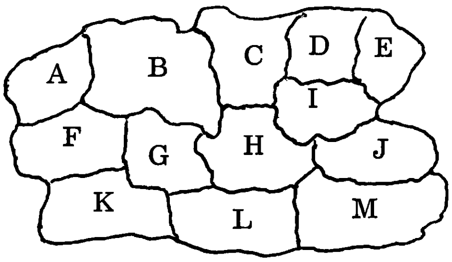
Both the costs and benefits due to construction and the 'other' costs and benefits due to the operation of the transport system fall mainly on people who work or live in specific areas. They will also be more difficult to calculate than the previously mentioned costs and benefits which can be calculated in the main by manipulating matraces which are produced as part of the transport model.

The costs which are associated with construction of transport infrastructure are, the direct resource costs of the construction which are borne by the government, and costs imposed due to the disturbance caused by the construction. Here and elsewhere government is taken to mean both the local authority and the national government. Disturbance costs are borne by the people who live and work and own property on or near the site of the construction, and by those who are delayed or otherwise inconvenienced on the existing transport system.

To the extent that compensation is payed for the disturbance caused, the incidence of the cost is transferred to the government. The cost of the disturbance to the owner of land which is used, can be taken as the market value of the land. Since the government pays market value as compensation, the cost can be considered to be transferred from the owner to the government.

Figure 3

User cost-benefit distribution surfaces.



Area of Study

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<tr><td colspan="3">F</td><td colspan="3">G</td><td colspan="3">H</td><td colspan="3">I</td><td colspan="3">J</td></tr>
<tr><td colspan="5">K</td><td colspan="5">L</td><td colspan="5">M</td></tr>
</table>

Schematic Representation

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Population ('000)

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Total Car user benefits (£M)

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Total Bus user benefits (£M)

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<tr><td colspan="3">+ 2</td><td colspan="3">- 2</td><td colspan="3">- 1</td><td colspan="3">- 8</td><td colspan="3">+ 4</td></tr>
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Per capita Car user benefits (£'000)

<table>
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<tr><td colspan="3">0</td><td colspan="3">- 1</td><td colspan="3">+ ½</td><td colspan="3">+ 1</td><td colspan="3">+ 2</td></tr>
<tr><td colspan="5">+ 3</td><td colspan="5">0</td><td colspan="5">- 2</td></tr>
</table>

Per capita Bus user benefits (£'000)

If full compensation is not payed, (for example it may be considered that market value is not adequate compensation for displaced property owners) only part of the cost is transferred to the government, the rest (that which is over and above the compensation) is still borne by those affected.

The costs caused by the operation of the transport system but not borne by the users are those such as noise and air pollution, which can in general be identified as falling on people in given areas unless the government pays compensation for these costs, in which case the incidence of cost is transferred to the government.

These costs both due to construction, and the operation of the transport system, which are not compensated for and so transferred to the government, can also be represented in map form, showing the level of costs per person for every area.

Having produced an anlysis of where costs and benefits fall it should be possible for the politicians and public to determine whether the distribution is acceptable or if an attempt should be made to change the costs and benefits falling on people in any given area. This analysis can also be used to test the effects, of raising or lowering the fares, or making other fare structure changes, on the users of public transport, other road users, and to the profitability, or need of subsidy, of the public transport operators. Conversely it can be used to assess the effects of subsidies to the public transport operators.

As an example of how the procedure would work, changes under consideration might give rise to an incidence of user benefits as depicted in figure 3. This would indicate that car owners from G, H and I, and bus users from G and M would suffer net losses. Car users from A would receive a considerably higher net benefit than those in other zones. It may be considered that all of these are unacceptable and in an attempt to make an improvement changes could be made to the transport plan. An orbital motorway from L to B could be deleted from the plan, the traffic management scheme in G H and I could be improved, and an increase in size and frequency of bus services to and from M could be added to the plan. These changes would then be tested and the new incidence of costs and benefits displayed.

There are problems, unfortunately, inherent in the proposal. They are similar to those which affect present methods, many of which are outlined in the next two sections. The final section deals with how they affect the proposal.

SECTION III

Chapter 6

THE INADEQUACIES OF PRESENT TRANSPORT POLICIES

"..... One of the major difficulties in dealing with past and present [transport] policy is that [the] aims [of transport policy] have seldom been clearly stated ..... Even the briefest of surveys of the field brings out the conflicting objectives in policy. Transport requires a substantial input of resources, both in construction and operation, it can impose substantial costs on others, it can aid the generation of employment and it must, in some fashion or other, be related to land use and social policies ..... Apart from direct transport objectives, transport can be used as an instrument of several policies." (Hart 1973). In general it has only been these direct transport objectives which have been dealt with in transport studies. To the extent that the recent sub-regional land use transport studies have considered both land use and transport at the same time it could be thought that they have used transport as one of the variables in their other policies. However the transport element of the plans have generally only been considered in terms of transport objectives. These objectives can be summarised as; to find the most economical provision of sufficient capacity to satisfy all demands for transport.

In evidence given to the House of Commons Expenditure Committee (1972), Professor Gwilliam outlined three main types of objectives, relating to efficiency, equity and environmental impact. To these might be added three more types of objectives, relating to accessibility, desirable resultant land use pattern and flexibility. Gwilliam went on to state that "the present state of the art appears to be that there has been developed an economic evaluation procedure for urban transport investment projects which can, potentially, rank projects sensibly on efficiency grounds, but ....." (House of Commons 1972 Vol. II p.279) that it does not cover the objectives relating to equity and environmental impact. Neither does it cover those objectives relating to accessibility, desirable resultant land use patterns or flexibility.

Severe criticisms can be made about the transport policies which are used in the formulation of transport plans (many of these are made in Plowden 1972). The common objective of these plans is that of "..... trying to find out how the demand for transport can be met for the least possible consumption of scarce resources, or seeking to discover how traffic (which term can be taken to cover both passengers and goods), should be allocated between road, rail and waterway, if it is to be carried for the lowest cost ....."[1]. This is fine as far as it goes, however the demand for transport is then considered to be independent of the amount of provision which is made

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1. From a description of the transport problem in Sharp (1965).

for it. If there is expected to be an increase in the volume of traffic, it is supposed that severe congestion will result, because the increasing congestion will not deter further traffic generation, with very serious economic penalties resultant upon the congestion. This has led to the "all demands must be met" syndrome. The implication of such a policy is that provision must be made for all supposedly inevitable increases, without regard to the cost of making such provision, and without evaluating the benefit or even desirability of such increases in traffic.

As well as not questioning the desirability of more traffic, there has also been an imbalance between the provision and further expansion of different modes of transport. There have been three underlying causes of this imbalance. Firstly the relative prices of different modes of transport have not reflected their relative marginal costs which has led to an inefficient distribution of traffic between modes. More specifically the marginal cost to the consumer of public transport and rail transport has been the same as its average cost, whereas the marginal cost to the consumer of private transport and road transport has been the actual marginal cost of its provision. This has produced a bias towards roads and private transport.

Secondly, the structure of grants for transport from central government has in the past been far from logical. There have been, and still are, separate grants at different rates for different types of transport. The structure of transport grants is at present being changed in England.

An outline of the new structure is given in Department of the Environment (1973). No change has yet been announced for Scotland.

Since the 1968 Transport Act "departmental" roads have been financed entirely by Central Government and "principal" roads have received 75 per cent grant. There have been up to 75 per cent grants for public transport infrastructure. This has been major rail projects, busway construction, railway rolling stock, resignalling schemes, improved systems of train control, automatic fare collection and capital expenditure on buses. Station improvements have received up to 50 per cent grant and bus stations up to 25 per cent. There are also grants for unremunerative rail and rural bus services.

In evidence given to the House of Commons Expenditure Committee (1972) C.D. Foster found "..... at least four principles at work, all of them breached in their observance:-

(i) A relation between percentage grant and the proportion of non-local traffic.

(ii) A principle of subsidising public transport in urban areas.

(iii) A principle of subsidising unprofitable public transport which is judged socially desirable.

(iv) A principle of subsidising capital, but not current expenditure" (House of Commons 1972 Vol. II. p.260)

In his evidence he concluded that the present grant system "..... biases the financial implications of various choices made by Local Authorities in ways which do not obviously serve public ends and may therefore be a misallocation of resources" (House of Commons 1972 Vol. II. p.265). In fact the present grant structure tends to encourage Local Authorities to adopt capital intensive schemes in their transport plans.

Finally there have been several bodies with separate responsibilities for transport provision at the local level.

This has all led to no overall control at local level, and, where comprehensive plans have existed, no overall implementation. There has also been a tendency for local authorities to form a biased transport policy because of the different rates of grant.

Chapter 7.

PROBLEMS OF TRANSPORT PLANNING METHODOLOGY

The discussion in this chapter will be confined to transport planning; its integration with land use planning will be dealt with in the next chapter. In the first part of the chapter general shortcomings of the transport planning process will be considered and in the second part the transport model used in most transport studies will be examined.

The very limited range of explicitly stated transport policies which are used when drawing up a transport plan, and the implicit assumption that demand is independent of transport provision are the root cause of most criticisms of transport plans. The lack of policies has resulted in cost-benefit analysis being the only evaluation which is made. Consequently, on the whole, only those factors which affect the cost-benefit analysis are considered and built into transport models. Criticisms of these shortcomings should not be levelled at the models but rather at the policies (or lack of policies) which led to their development.

The tendency in Transport Studies has been to produce a plan for a target date, some time 20 to 30 years ahead, without first giving any consideration to operational improvements which could be made in the immediate future. This, plus the conviction that all road traffic demand must be met, the grant structure, and the feeling that urban motorways are intrinsically "modern" and "progressive" and of high status relative to rail and bus, have produced a tendency for inflexible, capital intensive, road biased solutions to be put forward.

The transport models used in transport planning have in the past been considered as neutral and objective tools. However they can never be completely comprehensive, and to the extent that some factors are left out or are not represented very well, any resultant plan will be distorted. For example the transport model used in the Greater London Development Plan has been criticized because it "..... assumed that underlying travel habits do not change, when the whole point of the exercise ought to have been to look for ways of changing travel habits" (Robertson 1973). In the same way "these studies often assume that the basic relationship derived from survey and analysis of the present conditions provide a suitable basis for the 'vertical' projection of travel demands over a considerable period of time, often 20 years or more, yet it is frequently stated that these basic relationships cannot be transferred 'horizontally' from one area to another". (Jamieson et. al. 1967).

It is now time to turn to specific aspects of the transport model. Many of these problems or deficiencies are due to the previously mentioned limited transport policies and the assumption that demand is not related to provision.

Forecasting -

To produce estimates of future transport patterns the transport models require forecasts of a very precise nature of land use and socio-economic details. Forecasts must be made of the spatial distribution of "(housing, employment, shopping, etc.) ... also [of] economic growth (industrial production, household income, retail expenditure, vehicle ownership) and [of] social behaviour (working hours, shopping hours, the valuation of time, peoples resistance to travel over increasing distances)" (Solesbury & Townsend 1970). Not only must an average value be estimated for all these, but many must be estimated for each of many zones. There are very considerable problems involved in this type of activity.

First there is the problem of accuracy. The probable accuracy of any socio-economic forecast over even five years is likely to be low, yet forecasts have to be made over a period of twenty years and they have to be subdivided into many zones. As yet no evaluation of the likely level of accuracy of these forecasts has been made, let alone has any study been made of the resultant level of accuracy of the output of the transport model.

Secondly there is the problem of trend forecasting. When a secular trend is noticed and predictions are made that the trend will continue in the future, provision is often made for the predicted behaviour. However once the provision is made, it is often the provision, itself, which produces the predicted result. In other words the prediction is self-fulfilling. To forecast an increase in traffic (or a decrease) and make provision for such a change will in many cases ensure the change actually occurs.

Thirdly there is a problem because transport models are not based upon causal relationships, but rather on regression analyses of the present situation. It is assumed that the relationships between the land use and socio-economic variables and the transport patterns found at the present will be the same in the future, so that predictions of these future transport patterns can be made. However since there is no evidence of a causal relationship between the explanatory variables and the transport pattern, or even that the important variables are included in the regression analysis, there is no guarantee that the relationships will hold in the future.

For example, one of the correlations usually found is that between socio-economic characteristics, such as car ownership or the number of shopping trips made per week, and income level. This correlation is then built into the transport model. If it is forecast, that in the future the population from a given area will have a higher income level, it is assumed they will behave in the same way as people who have that level of income at the present. However it may be that many aspects of behaviour are 'controlled' by class rather than income level, so the projected behaviour is not valid. (The correlation between income and behaviour in this case is due to the correlations between income and class, and class and behaviour. Changing one, that between income and class may not alter the other).

Finally, regardless of how accurate the transport model may be made, the output can be no more accurate than the forecasts used as an input. To the extent that social and economic forecasts will always be uncertain, so too will the transport predictions.

Generation -

Stephen Plowden has criticized transport planners for confusing transport demand and transport usage (Plowden 1967). That is the assumption that trips will be made regardless of provision, which is one of the implicit assumptions in the transport model. Present travel patterns or transport "usage" are taken to represent present "demand". It is assumed that if the variables which "determine" present "usage" (and these do not include the level of provision of transport facilities) are forecast for some time in the future the future "demand" can be forecast. What is lacking is any consideration of the effect which the level of provision has upon the level of "demand" for, or more correctly, usage of, the transport system. The probable reason for ignoring this effect is that it is easy to recognise its existance but that it is very difficult to measure.

Distribution/Modal Split -

Most transport models either make a pre or post distribution modal split (some transport models, such as that used in the SELNEC study, treat the modal split and distribution as a composite process). That is the mode used to make a trip is either decided before the destination of the trip is decided, in all cases, or after, in all cases. Neither pre-distribution nor post-distribution modal split is particularly realistic in all cases.

There are also problems which relate to modal split alone. All models, of necessity, have to limit the number of alternative modes which are considered. However the exclusion of a mode from the model such as bicycles, makes the consideration of the use of that mode impossible throughout the whole transport planning process. Person trips are generally forecast on a household basis and consequently assume that if there is a car owner in the household, all members of the household will use it. However the car may not be available all the time or to every member of the household. For example, a wife will not be able to use the car to go shopping while her husband is at work (if he drives to work), teenagers will probably want to travel independently of their parents most of the time even when a car is available.[1]

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1. In evidence presented to the House of Commons Expenditure Committee (1972 Vol. II p.237) Dr. Meyer Hillman made a critical analysis of the assumptions of household car use.

Finally some transport models have been based upon considerations of the time distance between points only. That is the time taken to make a trip has been used as the only variable which determines the choice of destination and choice of mode. The use of time only explicitly excludes the possibility of considering the effect of, for instance, changes in price, such as a new fare-structure or parking charges. Recently the concept of a 'generalised cost' which is a composite function of time and cost has been introduced to overcome this problem. However this is still prone to difficulties due to the use of average values. (These are dealt with later).

Assignment -

The major problem in the assignment procedure is that in a complex network there is generally more than one route between any two points. To simplify the choice of route or "assignment" the usual procedure is to assume that all trips between any two zones travel on the "shortest" route which variously can be defined as that which has minimum distance, time, cost or generalised cost. Here and throughout this discussion only the distance function will be considered, but any of the other three functions (time, cost or generalised cost) could be used instead.

If two routes are of very similar "length" then all the trip makers are unlikely to perceive the same route as shortest and there will be a division of trips between the two routes. However a multiple route assignment, using some type of diversion curve procedure to divide the trips between two zones, between routes of similar "len gth", is computationally extremely complex, and it is almost impossible to spot or trace any errors in the computations. This is the reason for the use of the "all or nothing" assignment procedure, although it has acknowledged shortcomings. This is another area where the use of average values can cause problems.

Finally there are several more general points on transport models. First there is very seldom any detailed consideration in a transport model of the different travel patterns occuring at different times of day. The model will generally be of the conditions either for the peak hour or for the greater part of the day probably 16 or 24 hours. Loadings on routes for other periods (i.e. for 24 hours when the peak hour is modelled or vice versa) will usually be derived by multiplying the loadings by some average factor. This procedure will not be very accurate, since the variation from hour to hour, in load on any link, will vary between links. That is - there may be a very large difference between the average flow and peak-flow on one link, whereas there may be little or no variation on another. Second - there is no consideration of the dynamic effects of changes to the road pattern. That is no-one has an instantaneous awareness of changes in a network, so there will be a time after the opening or closing of any link in a network while the flows on each link find a new equilibrium level. At present no-one knows how long these transient effects last but they are probably of a reasonably short duration and of small overall effect.

Finally there is considerable variation in the level of accuracy of different stages of the modelling process. For example the calibration of a model will be taken to an accuracy of 5% or less whereas the forecasts on which any estimates of future transport patterns depend, will have a probable accuracy which is far lower than this.

In conclusion the transport planning process is at present based upon a very limited range of policies and so the evaluation of alternatives is extremely limited. It is this limited evaluation which explains some of the limitations of transport models. Others are explained by the difficulty of measuring the size of the effect of provision on level of usage, and the lack of evidence that the relationships built into the model are in fact casual relationships. Finally, since the accuracy of the output can be no greater than that of the input, and a large part of the input consists of socio-economic forecasts which are not likely to be very accurate, the accuracy of the output from the transport model will not be very high.

Chapter 8

PROBLEMS OF LAND USE AND TRANSPORT

In their review of the historical development of land use transport studies in the United Kingdom,Solesbury and Townsend (1970) conclude "that activity and transport systems together create and also satisfy the travel demand, and that both are variables. The preparation of land use and transport plans must, therefore be a closely interwoven process ....." However they found that there were several reasons why land use and transport planning had not been fully integrated in the past and why the intregration would be difficult in the future. These reasons can be summarised as, the separate responsibilities of land use and transport planners, the lack of and accuracy of data, trend forecasting of land use, rather than control over development (due to the North American origins of transport planning techniques), and the lack of appreciation of the sensitivity of one variable to another. These and other factors affecting the integration of land use and transport planning will be dealt with in this chapter.

Due to the influence of the North American studies, the first land use transport studies in the U.K. were extremely one sided. Land use was taken as an exogenous variable. The land use projections used were those contained in the existing development plans which covered the area of their study. They merely pieced these together jigsaw fashion. Later it was realised that this procedure was unsatisfactory since, as Jamieson, MacKay and Latchford (1967) demonstrated in a theoretical study; "Although many of the costs of a major development are not significantly affected by the planning layout, this study demonstrates that transportation costs can vary significantly". That is, an optimum transport pattern requires the planning of both the land use and transport systems.

The proper integration of the two planning processes has been and is hampered by several factors. The first is that the two activities have been carried out by two separate professions. Transport planning by Civil/Highway Engineers, and land use planning by Town planners. This has created a position where the participants in a land use/transport planning study are unlikely to be familiar with all the relevant interactions involved due to their solely "engineering" or "planning" background. "The opportunities for cross links between the land use and transport analyses are multiple, but the techniques appropriate to the organization and management of such multi-disciplinary exercises are only slowly developing" (Solesbury & Townsend 1970).

Another related factor is that although land use and transport planning are both the responsibility of the local authority they are discharged by separate departments under separate committees. This has resulted in a minimum of co-ordination between the two processes and it is far from the required integration. Re-organisation of local government may provide an opportunity to overcome this problem, however the indications are that it will not be taken up. The Patterson report on management structures for the new local authorities in Scotland (Working Group on Scottish Local Government Management & Structures 1973) suggests that land use planning should come under one of the policy committees whilst transport provision and presumably its planning should come under one of the service committees.

At a more technical level there is a problem of incompatibility between the levels of detail of data used in the two different planning processes. A transport study will generally require a level of data from the planning departments in the area it covers which the departments themselves do not use, especially in the forecasts of future land use and socio-economic patterns within the small zones used by the transport planners. If the development plan is not being reviewed at the same time as the transport plan either a non-statutory review has to be made of the development plan, or predictions must be made on the basis of the best estimate of current trends. Neither is very satisfactory as they both tend to lead to a situation in which the planning departments are not committed to the land use input to the transport plan. This will undermine confidence in the transport plan.

Related to this problem of different levels of detail in data, is that of accuracy and how changes in input will affect the output. To date very little is known about the extent to which divergencies can be allowed in the land use pattern before the transport pattern is seriously affected. This means that as yet there can be little guidance from the transport plan as to how strictly land use patterns must be enforced by development control because of the transport plan. There is also little understanding of the effects which even small changes in transport networks have on land uses.

So far in this analysis transport, land use and their interaction have been considered within a static framework. However in the 'real world' transport and land use interact dynamically. Changes in land use produce changes in the demand for transport and changes in transport infrastructure, or more correctly changes in accessibility, will tend to produce changes in land use. Very little is known about this effect let alone is anything done. "In fact, even a methodology for analysing the impact of transportation on the economic and population growth of a region seems to be lacking". (Rama Sastry 1973)

When more is known, it should be possible, and indeed it will be highly desirable, that transport planning should be used as a tool of the land use planner. Potentially the control of accessibility, and consequently of demand for land use change, is one of the most powerful tools in the land use planners cupboard.

SECTION IV

Chapter 9

PROBLEMS OF COST-BENEFIT ANALYSIS

The major problems of Cost-Benefit Analysis are in the fields of enumeration, evaluation, the choice of a rate of time preference, and of project selection. Most of the problems are concerned with the evaluation of the costs and benefits.

Enumeration -

Ideally all the costs and benefits associated with a project under study should be considered, however there are problems in doing so. The first is that it is often difficult to include all costs and benefits without any double counting, and the second is that some of the costs and benefits may be unforeseen, or be intangible. Some intangibles such as deaths and injuries may be simple enough to enumerate, but others such as visual intrusion will be very difficult. In most transport cost-benefit analyses only direct user costs and benefits have in the past been considered. This has lead to wide-spread criticism of cost-benefit analysis for ignoring such things as the effects of transport projects on the environment and on groups of travellers not considered, such as cyclists and pedestrians.

Evaluation -

Most of the benefits in a cost-benefit analysis are external to the body for whom the analysis is made. These external benefits are due to increases in consumers' surpluses. Their evaluation is based upon two assumptions. The first is, that along the small element of the demand curve over which the change takes place, the marginal utility of money is constant. To the extent that it is not the calculated value of the benefit will be in error. The second assumption is that utilities are comparable. This is the simplifying assumption mentioned in Chapter 3 by which questions of interpersonal comparisons are ignored. However it is in itself a comparison of the utility different people attach to money. The result is that cost-benefit analysis is based upon the subjective judgment that everyone attaches the same utility to the same monetary unit.

As mention ed in Chapter 3 evaluation is based upon market determined prices, since they are the only objective approximation to marginal social values. If the project is so large that it alters prices within the economy, the prices prevailing at the initial date will not reflect values at the end date. In this situation market prices must be used with caution. Theoretically a general equilibrium model would give a better indication of the effect of the project but it is impracticable in real situations since it requires full knowledge of all supply and demand curves.

'Second best' -

For the market to produce an 'efficient' allocation of resources, prices should reflect marginal social values. If they do the ratio of price to opportunity cost should be the same in all sectors of the economy. There are, however, cases in any modern western economy where this condition does not hold. An example of this is given by wages. They will probably rise when there is a labour shortage but will not fall when there is a surplus, so preventing the market from achieving an 'efficient' allocation of labour.

In this situation of prices not reflecting costs the 'optimal' distribution of resources is known as the 'second best' solution. However in an article on welfare aspects of cost-benefit analysis, Krutilla (1961) found that there were even arguments that denied the existence of a 'second best' solution[1], but he carried on to offer several solutions to this problem. Two were criteria for considering whether changes were, or were not, improvements. One was put forward by McKean (1958). It considers that an improvement is likely to be achieved if production is increased where price exceeds cost. The other is that of Eckstein (1958) following Little (1950), that in most public utility cases prices are a good approximation to marginal costs, and will suffice for decisions, but in some situations (when assumptions are not met) other measures of costs and benefits must be used.

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1. These arguments were put forward as the negative theorem in "The General theory of Second Best" by Lipsey and Lancaster (1956).

Krutilla concluded that there is no theoretically correct solution and that although academics should continue to say so, the practising economist in government will "..... be grateful for ..... even a perforated rationale to justify recommendations "in the public interest"" (Krutilla 1961).

On a more practical level Foster and Beesley (1963), in their study on the Victoria line, were critical of the relative prices between road and rail transport and considered that road transport was under priced in relation to rail and so produced a non-optimum allocation of resources between the two. They stated that "..... if the Government should decide ..... that these are the "right" relative prices, than it would be logical if it wanted them reflected in investment policy. This would imply that investment would be biased towards heavy urban road investment even if it should be cheaper to build or improve railways. However, the Government might take up an intermediate position declaring that the prices were 'right' because a change would be politically undesirable or impossible, but that investments should be made as if the prices were corrected so that both reflected the real costs involved ..... The last possibility is that the Government acts to correct the present relative prices, in which case investment would proceed on the assumption of the corrected prices" (Foster & Beesley 1963 p.58).

Finally, when considering 'second-best' situations caused by market imperfections "Only those divergencies which are immediate, palpable and considerable ..... deserve our attention" (Prest & Turvey 1965).

Intangibles -

Having found a suitable measure for the enumeration of intangibles such as deaths or visual intrusion a method must be found to give them some value. The basic problem is that, strictly, monetary values are only valid if they are determined in an exchange situation. This poses an extreme problem when evaluating intangibles because they are not traded in exchange for money. Several methods of evaluation have been suggested, however as they all produce a result which is subjective, none have the same degree of objectivity as market determined prices.

As an example one method put forward is that for determining the value of life. The value which decision makers place on life can be imputed from decisions which involve the implementation of schemes, that involve the saving of lives. Once all other benefits have been accounted for any excess expenditure can be attributed to the saving of lives. If the number of lives saved can be determined the 'value' of each life saved can then be implied.

There are several drawbacks to this procedure. If it is used to determine the value of all intangibles in every decision, the only values available will be those used in the first decision that was made in this way. Second no more than one intangible can be involved in the decision which is used to imput its value without entering into other problems.

Value of time -

One of the major intangibles in transport cost-benefit analyses is time saving. In fact in most studies it has been found to be the major benefit. Although the enumeration of time savings are simple enough their evaluation is difficult.

Savings of time made during a person's working hours are generally valued at that person's hourly wage rate. This is on the basis that the employer, and so the community, receives this amount of benefit. It is however only valid if the wage rate accurately reflects the marginal value of the time saved and that the time saved is actually used in a productive manner. The value of 'leisure' time presents more problems. There is no direct way in which to value it, so some indirect way has to be found. These methods will imply a value from any situation in which it is assumed travel time savings are being traded off against some other commodity which does have a price. Examples are time savings due to a faster but more expensive route or mode of transport, or due to living in a more expensive house which is closer to place of work. One of the many problems with these methods is that time saving is not the only consideration when making these types of choice.

At present, probably due to the lack of any concrete evidence to the contrary, the value of time savings are assumed to be proportional to their length, that is, a time saving is valued at the same rate regardless of how long it is, so that the net benefit of sixty people making a one minute saving is considered to be the same as that of one person making an hour's saving. There is also the possibility that time-savings of the same 'type' may have 'values' which vary due to the time of day or the purpose for which the trip is made.

Time preference -

The effect of the choice of a rate of time preference is to determine the relative importance between investment in the present and future consumption, and also between consumption now and in the future. In this respect benefits can be considered as consumption. The higher the rate of time preference the less important is future consumption as compared with consumption at the present. For example a discount rate of two per cent would value a benefit of one pound incurred in 114 years time at 10 pence whereas at 10% a one pound benefit would be valued at approximately 10 pence if it were incurred only 23 years hence. This means that the higher the rate of return the shorter the time over which the project need be considered since any costs or benefits incurred after the end date can be considered to be of minimal importance since they have such a low present value.

At present with the prevailing high rates of interest, the period of time over which it is meaningful to consider a project is in the region of 20 to 30 years. However, the use of such high discount rates can be considered as a very short sighted approach to decision making. This is a reflection of the real problem of the selection of a rate of time preference which stems from the possibility of a divergence between the social time preference, social opportunity cost and financial rates of return.

A financial rate of return reflects the collective 'private' time preferences of the owners of capital, whether they are individuals, institutions or government. There is no reason to suppose that it should be the same as the social time preference of the community. In fact "some writers (Pigou (1932), Eckstein (1958) and Marglin (1963) believe that social time preference attaches more weight to the future than private time preference, and that it is the former which is relevant for determining the allocation of society's current resources between investment and consumption". (Prest & Turvey 1965).

However as Prest and Turvey mention there are two difficulties in using a social time preference rate of return. One is to determine the rate[2] and the other is that if the public and private sectors both act in the same field (i.e. state coal and private oil), non-optimal resource allocation will result.

The rate used in most calculations is the government borrowing rate which is taken as a reflection of the social opportunity cost rate. The problem of choosing a rate usually receives little attention and as Prest and Turvey (1965) conclude "The truth of the matter is that, whatever one does, one is trying to unscramble an omelette, and no-one has yet invented a uniquely superior way of doing this".

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2. Prest and Turvey mention that a method is suggested by Feldstein (1964).

Project Selection -

Project selection is a simple enough process provided a method of selection (such as choice of the projects with highest benefit-cost ratio until the budget is exhausted) can be agreed, and that there are no mutually exclusive schemes. If there are, "one project may have a lower benefit-cost ratio, yet will be preferable if the extra benefits exceed the extra costs". (Prest & Turvey 1965 p.704)

The real problems of mutually exclusive schemes occur when projects are interdependent. That is if the size of the costs or benefits of one scheme depend upon whether or not another scheme is implemented. In this case both schemes should be considered separately and together as three mutually exclusive projects.

In an urban context a transport plan can be considered to consist of a very large number of interdependent schemes which may or may not be implemented. To be rigorous all the combinations of possible schemes should be considered, within any budget constraint that may exist. This would produce an impossibly large number of schemes to be considered, since each would separately require the running of the transport model to produce the estimated travel patterns on which the cost-benefit analysis is based.

Accuracy -

Finally there are considerations of how accurate and value free cost-benefit analysis is as a tool of decision making. Firstly, unless constraints are imposed cost-benefit analysis can not be used to evaluate policies other than on the basis of what is the most efficient use of resources. In its 'ideal' form it merely tries to reproduce the effects of market forces in areas in which they do not act. It is not a suitable method of analysing schemes which are created to satisfy policies which have non-economic ends. That is, ends which involve the production of a result which is intangible, such that they cannot be measured in physical terms, or if they can be measured, can not be valued satisfactorily in monetary terms since they are not traded in a market.

The use of cost-benefit analysis in the consideration of programmes within any field will tend to discourage the introduction of any policies other than that of economic efficiency which is implicit in cost-benefit analysis.

There are several areas in cost-benefit analysis where there is room for considerable variation. Just two of these are in the values attached to intangibles and the choice of the rate of return. None of these choices are value free and they may well affect the outcome of the analysis. The extent to which the results of an analysis can vary is illustrated in an example given by Prest and Turvey (1965). It is about calculations on the cross-Florida barge canal[3] in which the Corps of Engineers produced a benefit-cost ratio of 1.20 and consultants produced a ratio of 0.13. Prest and Turvey comment

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3. From Prest & Turvey (1965) the example is taken from U.S Senate (1963)

that "To what extent the divergence is due to the facts that the Corps likes to build canals and that the consultants were retained by the railroads, and to what extent it is due to the intrinsic impossibility of making accurate estimates is left entirely to the reader to decide".

Conclusion -

Firstly cost-benefit analysis is only a method of measuring how 'efficiently' resources are allocated. It cannot consider 'non-economic' ends such as the full effects on the environment or the effects on future land development.

Secondly and probably most importantly, it is based upon assumptions of the comparability of utilities and the acceptability of the Kaldor-Hicks criterion for improvement. That is, that an improvement will be made if there is a net gain even if this is at the expense of some people suffering an uncompensated loss. So from the very start cost-benefit analysis cannot be considered as being 'objective'.

Thirdly, enumeration, evaluation and the choice of a rate of time preference all contain difficulties. All three contain subjective elements, and margins of doubt and error, so the results are liable to be non-conclusive.

Cost-benefit analysis is therefore a subjective and error prone method for assessing how schemes measure up to 'efficiency' criteria. However as Prest and Turvey (1965) conclude in their review; "The case for using cost-benefit is strengthened, not weakened, if its limitations are openly recognised and indeed emphasised".

SECTION V

Chapter 10

DIFFICULTIES OF THE "ALTERNATIVE APPROACH"

There are several areas of difficulty inherent in the Alternative Method put forward in Chapter 5. These are problems of its own, those which it has in common with cost-benefit analysis, those due to the transport input, and those which will occur if the worst of the deficiencies of the transport planning methodology are removed.

Own difficulties -

There are many possible groups, and types of costs and benefits, which will lead to many cost-benefit distribution surfaces being produced in each evaluation. Either all the surfaces could be presented, in which case the effect may be totally confusing, or a single combined surface could be produced, in which case assumptions on inter group utility comparisons must be made, or a small number of composite surfaces could be produced, which would entail a trade-off between confusion and assumptions.

The types of groups which can be identified include those by income, by car ownership, by tenure, etc. Costs and benefits can be separated into those accruing to users and non-users. They can be further divided. For example user benefits can be sub-divided by trip purpose, and non-user costs can be classified as being due to causes such as noise and visual intrusion.

If all the surfaces are presented to the decision maker, and there could be as many surfaces as the product of the number of groups and the number of cost and benefit types, he may not be able to comprehend the overall position. This is a similar problem to that of comprehending a Planning Balance Sheet (for example see Lichfield 1966).

On the other hand, if the surfaces are combined, an assumption will have to be made regarding the weighting of the costs and benefits. The simplest method would be to use the same weighting for all costs and benefits, or in other words to use no weighting. This however still makes an assumption that all groups attach the same utilities to monetary values for all cost and benefit types.

Difficulties in common with cost-benefit analysis -

Enumeration. There are still the questions; has everything which is relevant been considered? and how are intangibles such as 'visual intrusion', or 'severance' to be measured? However, if, at the same time, other evaluations are being carried out, and this modified cost-benefit analysis is no longer considered 'comprehensive', these two questions are not so important.

Evaluation. As with cost-benefit analysis there are several difficulties in evaluation. The market does not operate perfectly, so prices will not necessarily reflect social costs or values. Intangibles, because they are not traded have no market value, so they have to be valued by other methods which will probably require the valuer to make 'value judgments'. There are still the difficulties of time valuation.

There is also an additional problem with time valuation and other values. Should an average value be used or not? An average value could be justified on the grounds that it will ensure that benefits (for instance time saving) accruing to the higher income groups would not be over valued compared to other groups' benefits. This would be an 'equity' valuation. On the other hand it could be argued that the values of each group should be used. In the case of quantities such as time savings these values would be the same as the behavioural values used for modelling purposes. Both behavioural values and equity values will tend to bias the information presented to the decision maker. If behavioural values are used the most noticeable quantities, and so those most liable to be changed, will tend to be costs and benefits to the rich, whereas if equity values are used those quantities which attract attention may not be valued at all by those they affect. This again is an inter group utility comparison problem.

Time Preference. If some of the costs or benefits for any group change significantly through time all costs and benefits will have to be discounted. This raises the question, what discount rate should be used, the current financial rate of return, or the social time preference rate of return? The groups which receive costs or benefits which have to be discounted may well have different time preferences. If a social time preference is to be used the question of whether an average or a group value should be used will have to be asked.

Difficulties due to the input -

Just as the accuracy of the output from a transport model depends upon the accuracy of the input, so the accuracy of any cost-benefit analysis will depend upon the accuracy of its input. If sensitivity tests are carried out it may well be found that the size of costs and benefits is most sensitive to the socio-economic forecasts, and that the incidence of costs and benefits is most sensitive to the transport system. For example a doubling of growth in G. N. P. will probably increase everyones' costs and benefits by about the same factor provided it is not accompanied by a fundamental change in the distribution of incomes. On the other hand the costs and benefits due to the construction of a radial transport facility to the north of a city will fall mainly on those living to the north, whereas if the facility was on the south of the city most of the costs and benefits would fall on people living to the south.

Difficulties due to improvements -

Policies. If more policies are explicitly pursued in transport planning more evaluations than those of cost-benefit analysis will have to be made. One possible policy concerns equity, and the alternative method put forward in Chapter 5 is to deal with it. However, if, in the same iterative process of plan preparation, other policies are also considered, some way will have to be found by which the results of the evaluations for each policy can be combined.

Transport Model. There are several improvements which could be made in the transport modelling process. Account could be taken of the effect that provision has on demand. Consideration could be taken of alternative land use patterns, and the effect transport has on land use changes, instead of the single "trend" projection which has been used in the past. A more realistic assignment procedure which can split each set of interzonal trips between several routes could be used rather than the "all or nothing" assignment procedure which places them all on one route. Each of these improvements will increase the complexity of calculation, particularly of the incidence of costs and benefits. The first two will create great difficulties in calculations of costs and benefits, because there will no longer be an easily calculable "do nothing" situation upon which to base them.

Conclusion -

One of the main problems is the combination of quantities which are valued differently by different groups. Should a single value be used? or should each groups' value be used to value their own quantities? and if so how can the values be determined? Just as welfare economics offers no satisfactory solution to the problems of making interpersonal utility comparisons, it would appear that no satisfactory answers can be given to these questions.

APPENDIX - PROBLEM OF THE USE OF AVERAGE FIGURES

There will be a problem in any field where pairing of different elements is modelled by collecting the elements into groups, and pairing the groups. It may well be that the paired groups contain very few paired elements (see figure 4).

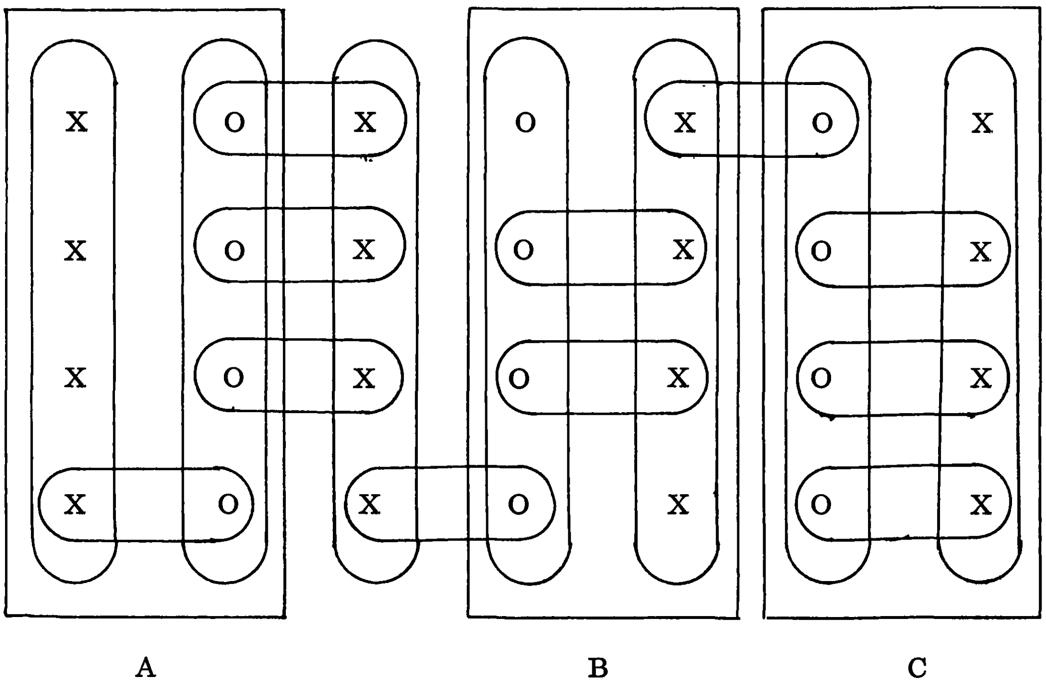
In many cases the pairing of elements is due to individual decisions. In the model these are fairly realistically represented by pairing elements which produce a minimum (or maximum) for a function which is dependent upon characteristics of each element. However the problem arises when these individual pairing decisions are combined into group pairing decisions. These are again made on the basis of minimising a function which is dependent upon average values of the characteristics of each element. If there is a large spread of values of the characteristics, there is liable to be a significantly large mis-match of elements in the paired groups (see figure 4).

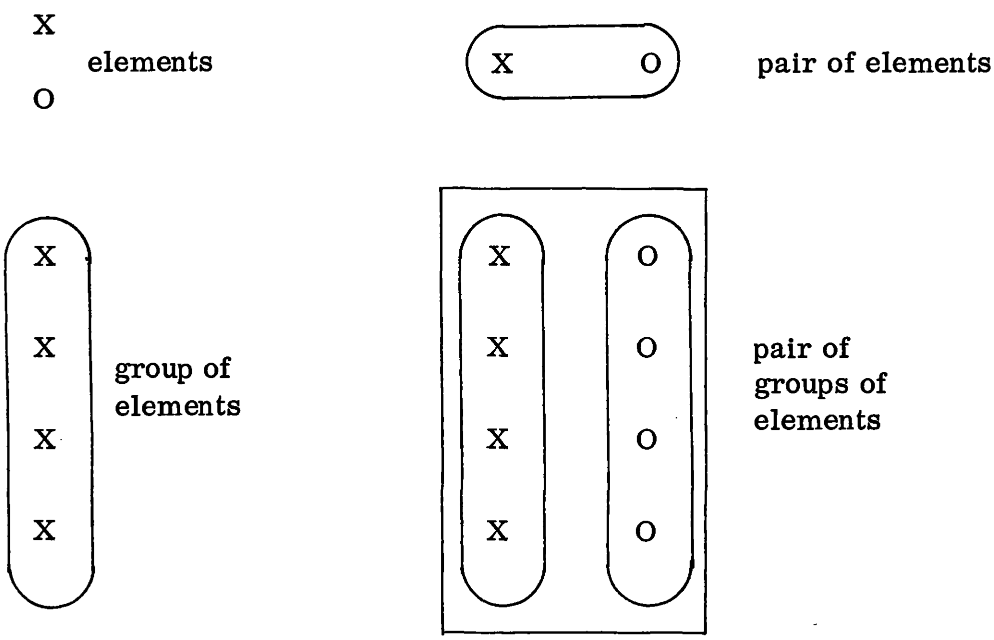
Examples

Two examples are given. One from transport planning, another from the methodology being developed in sub-regional studies. They are the

Figure 4

Pairing of elements and pairing of groups.





The separate elements in one group of a pair need not be paired with elements in the other group of the pair. Pair A has a large mis-match of elements whereas Pair C has a fairly good match of elements.

assignment process in transport modelling and the use of development potential surfaces in strategy generation for sub-regional studies (see figure 5).

Assignment - A common method of assignment, at present, is to assign all persons trips (on a given mode) (elements) between two zones to the 'shortest' route (element) between those zones, where shortest is defined in terms of the generalised cost.

A fairly accurate predicition of individual behaviour could be made on the basis of assigning separate person trips (individual elements) to the "shortest" perceived route (individual element) between origin and destination, defined in terms of an individual generalised cost. (A function of the characteristics, value of time, time, and cost of the individual elements). However in the model the difference in route lengths is only that occuring between zone centroid and zone centroid. There is no account of the variation in length due to the finite size of the zone. There will also be differences in 'perceived' lengths due to variations in individuals' variation in time valuation (and also due to errors in perception). In other words within any group of person trips there will be a variation in time valuation, and within any corresponding set of routes there will be a difference in the perceived lengths due to differences in time valuation, errors in perception, and the finite size of zones. These possible differences in perceived lengths may be larger than the differences in route lengths, in which case not all trips between the two zones will use the same route. In the model all the

Figure 5

Elements, characteristics, sets and pair.

Assignment

Elements	Individual Person Trips between zones	Routes
Characteristics	Value of time	Time Cost
Sets	All trips between two zones	'Shortest' route
Pair	Trip and route	

Development potential

Elements	Land use i.e. housing	Plots of Land
Characteristics	Importance attached to:- Slope, Site size, 'Environmental quality' Accessibility to jobs " " recreation	Slope Site size 'Environmental quality' Accessibility to jobs Accessibility to recreation
Sets	All of one type of land use i.e. housing	All under-developed plots within Km grid square
Pair	Land use and plot of land	

trips are placed on the shortest route on the basis of centroid to centroid, shortest generalised cost, based upon an average value of time, which, in this case, will result in some of the trips being assigned to the wrong route.

Development potential - A development potential surface can be used to locate new development when producing a strategy for a development plan or sub-regional study. (This method was used in the Coventry, Solihull, Warwickshire Sub-Regional Planning Study 1971.) As an example the location of new housing will be considered. It is assumed that housing is located on the basis of the best trade off between several factors or characteristics of each available site. (Each location decision is an element and each site is an element. The trade offs are the characteristics for each location decision). The site characteristics might be slope, site size, 'environmental quality', and accessibility to jobs and to recreation.

The development potential surface is produced by assessing the average value of each factor for all available sites in each kilometer grid square (group of sites) in the area under study. These separate potential surfaces are then combined to give a composite potential surface by adding the separate surfaces multiplied by an average weighting. This average weighting is assumed to represent the average trade off between the different factors. This produces a surface which 'theoretically' shows where the "best" sites for new housing are. The new housing is then allocated (housing location group) to sites in those kilometer squares which have the highest development potential.

The problems arise because separate location decisions will have non-average trade offs, and will in this terminology, be located on the basis of a different surface, and the values of the characteristics of the elements (sites) in each group (grid square) will vary so that any surface produced on the basis of the Km grid squares will only give an average of the potentials of the sites in each square. This means that if there is any difference in trade off (which there is likely to be, for instance between single private houses, private developers' and local authorities', housing estates), and any significant variation between the characteristics of each site within a square, the model will locate the housing on a surface which would not be used in individual decisions and does not represent the true development potential of each site. There will consequently be a possibility of a serious mis-location of new housing sites.

(17,000 Words)

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