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TOPIC II

ECONOMIC CRITERIA FOR THE MAINTENANCE, MODIFICATION OR CREATION OF PUBLIC TRANSPORT SERVICES WHICH MAY NOT NECESSARILY BE PROFITABLE

1st Part

Urban and sub-urban transport

M.E. BEESLEY

2nd Part

Transport outside towns
(passengers and freight)

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URBAN AND SUBURBAN TRANSPORT

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SUMMARY

ECONOMIC CRITERIA FOR THE MAINTENANCE, MODIFICATION OR CREATION OF PUBLIC TRANSPORT SERVICES WHICH MAY NOT NECESSARILY BE PROFITABLE: URBAN AND SUBURBAN TRANSPORT

I. Introduction

Some preliminary definitions of the terms in the title of this paper are necessary. First, 'public transport' is understood to apply to any form of transport to which a traveller has, or might have, access and in which the service performed for him is not provided either by himself, a member of his household or by an organisation to which he belongs. Thus we shall be concerned principally with passenger transport, as befits a concern with urban and suburban transport, and the definition is deliberately drawn to include potential forms of transport, thus avoiding any narrowing legal or conventional connotation such as may now define the scope of public transport in practical terms. The phrase 'services which may not necessarily be profitable' implies a fairly specific structural context in which the services are performed, namely that the organisations (or at least one) charged with providing them are separate from a 'governmental' body. This body, which may be local or national, is seen as taking decisions on behalf of a wider public, in response to considerations which may diverge from those important to a set of present or potential urban or suburban travellers. Thus we have a world in which there are at least three distinguishable parties - those who use public transport, those who provide it, and those who govern. Transactions between these parties may - but not necessarily always - take place in cash terms. Public transport, however, is deemed to be operating also in a situation where it has to purchase its inputs; hence, depending on the revenues it receives from the public, it may make an accounting (cash-flow) profit or loss. Where a loss in whole or in part is paid for by the 'government' we have a subsidy or subsidies.

The justification for such subsidies in urban and suburban conditions is the main theme of this paper; these will run not only in strictly economic terms (i.e. concern arguments solely to do with the creation of real income or wealth) but also will include those often classed as 'non-economic', in particular arguments proceeding from views of a just distribution of wealth or income, and the quality of life as reflected in non-monetary transactions. Thus the issues typically comprehended in 'social cost-benefit' analysis of transport infrastructure are included in principle.

Since there are necessarily many elements in discussion of 'not necessarily profitable' services which will be common to urban and non-urban services, they should proceed from the same framework. Cost benefit analysis provides this. We should note, however, that arguments within that framework will not necessarily or even usually imply that a service should not be run to make a profit; so subsidies for, or indeed taxes on, services may not be the indicated outcome. A final preparatory point: the use of the words 'maintenance, modification or creation' means we must consider not only the preservation or adaptation of existing public transport services but also the conditions under which innovations in urban public transport may be expected to increase.

This brings up the issues of the relationships between the parties to transactions that may involve subsidy. A government(1) must not only rationalise subsidies in terms of benefits and costs to various interests, with given initial preferences, technological opportunities, and incomes, etc. but it must also consider how its choice of method of subsidy will react upon the operators' willingness and ability to innovate. Operators are traditionally (in the United Kingdom at least) highly suspicious of the loss of independence they associate with increasing subsidy of any kind. From a government's point of view, whether independence is important may well depend mainly on its connection with innovation, for it is probably true that the near-universal decline in conventional urban passenger transport can only be arrested by rather radical innovation. So, if a government must be concerned, in principle, with the conditions for innovation - for example, the generation of information to define appropriate new forms of transport, the

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(1) Either national or local; we use the term 'government' to cover either in this paper.

incentives operators have to formulate new ventures, to capture the resources for them, to market them, and to persevere with the search for alternatives. We shall see that the method of subsidy does have a bearing on these, though it is impracticable in this paper to explore fully the complex relationships involved.

II. The decision-making context of subsidies

To organise the discussion it is helpful, if a little idealistic, to think of a model of a coherent decision-making framework in which a 'government' settles on the subsidies, if any, to be offered to the urban passenger operator(s) as follows:

A proposition for subsidy is made (or propositions made); the 'government' considers whether these fit the urban or other policy objectives i.e., calculates the expected pay offs. Pay offs relate to several different objectives, which are classified:

- first, macro-economic objectives (a subsidy is useful to combat inflation, and therefore to promote economy-wide growth);
- second, micro-economic objectives, such as, a subsidy is useful to 'correct' for imperfection of the existing pricing system (e.g. failure to count congestion costs in prices facing urban travellers; or to secure the benefits of economies of scale in provision of one or more forms of public transport);
- third, efforts to provide for specific sections of the community (e.g. the old, young and racially under-privileged).

Pay-offs from subsidies are compared to pay-offs from alternative means to the same objectives (e.g. a direct income subsidy, or the imposition of alternative pricing schemes) so that potential benefits of the options can be laid out. The alternative means of raising the money for the subsidies are reviewed and their impacts on interested groups evaluated, both in and outside the urban area. The changes in resource costs arising from the public operator's change in service levels is computed, using appropriate shadow prices where necessary, and the resource-cost implications of alternative financing methods similarly resolved, including the performance of operators in their non-subsidised activities, if any. If necessary the trade-offs implied in the comparison between (a) benefits to urban travellers (b) disbenefits to other interests asked to finance operations, and (c) changes in resource use are subjected to weighting by a high-level government decision, or perhaps some form of voting. The resulting decision, whether positive or negative, is implemented. Consequent events are monitored, in an analytical framework, which may have to include neutral control groups, set up for the purpose of recognising the causal connections between subsidy and benefits and costs. If monitoring shows deviance, corrective action, perhaps invoking the analytical chain again, is undertaken. Thus information generated in the process as a whole is fed back to improve appraisal and performance of the system as a whole.

This is a sketch of the cost-benefit analysis of urban transport subsidies in a decision-making context. It is useful because it points up alternatives, costs and benefits, and the dynamics of decision making. The bare description suffices to show how improbable it is that such a model can be fitted in its entirety; but as an organising principle, to show how what arguments we do have relate to one another, and to suggest improvements, it is probably as good an approach as we have, and in general we shall follow it. More important, perhaps, it serves to show the direction of change towards which practical subsidising actively will have to go if it is to become more consciously rational in relating means to ends. Clearly present decision-making processes diverge considerably from the specification.

For one thing, the perception of the need to subsidise has overwhelmingly <u>not</u> occurred to governments as part of an explicit programme for implementing objectives such as we have posited in our 'ideal' model. Urban transport typically attracts the proposed remedies when already in deficit, or nearly so. There appears in these circumstances a very general appeal to supposed benefits and little rationalisation of costs, simply because even if the machinery for analysis were there, the time for it is lacking. So alternative courses of action are not obviously pursued. In terms of the model the proposals for subsidy must be a result of a directed search for alternatives; and if this is to be achieved, appropriate relations between the parties must be devised.

Again, in practice, relationships with prospective receivers of subsidies rarely start out at arms length. Where, for example, the relevant 'government' is a local authority and a franchise, for exclusive operations in its area, has been given to an operator for some years, a shared set of attitudes may arise between operator and the government, reducing the probability that alternatives will be sought and evaluated. So also with operators forming part of national concerns dealing with central governments. Even if there is a strong motivation towards more rational decision making, it may well be that objectives can only be classified by a government by reacting to concrete proposals, particularly where complex divergent interests are involved. Separation of the stages of decision making is difficult in practice, but if it can be achieved, will probably improve rationalisation.

The adoption of more rational decision-making techniques in this area probably requires more clarity of objectives and, as we shall see later, much development of the technique and data for measurement of the pay-offs and costs involved. But more than this, it requires very careful attention to the organisational capabilities of the government and the operators or other aspects of their relationships. For example, the government may need to develop its own independent capacity for generating proposals for subsidies, as implied in the model, for its interest in initiating proposals will often diverge from that of the operators. And the government may well have to consider how the form of subsidies, if they are adopted, will affect the current performance of the operator(s) in other respects than the subsidised services. (An outstanding example of this kind of problem has occurred with the United Kingdom Transport Act of 1968, in which the general railway subsidy was replaced by a system of 'social' subsidies for specific services intended to be consistent with the overall need to encourage the commercial viability of British Railways i.e. to encourage it in profit-maximising behaviour. We shall draw on this experience in discussing the operation of subsidies). Thus in parallel with the question, raised in the last section, of creating conditions for innovation in public transport, we have to consider the problem of improving the Government's performance in decision-making. As there, all we can hope to do in a very complex problem taking us in principle into areas outside the legitimate scope of this paper is to point towards some very tentative advice.

III. Arguments for subsidies

Arguments for deviating from self-finance by transport operators have, especially recently, become more specific as to objectives, and these increasingly concern urban issues, e.g. the problem of relieving congestion and the reducation of external disbenefits of vehicles such as noise and fumes. These have tended to supersede more general arguments about the desirability, on grounds of a 'correct' allocation of resources, of departures from a requirement for balanced budgets. Equally important, and prompted especially by United States experiences, arguments for subsidies on grounds of favouring particular groups of the population have become more instrumental. Thus arguments about the means of continuing traditionally favourable treatment of the aged and the young have yielded to much more specific questions about what role public transport can play in overcoming, with the aid of subsidy, the disadvantages with respect to journey-to-work experienced by the poor and those who suffer from segregation in the housing market. We shall select what appear to be the more important of these arguments for analysis. But the question whether there is any general justification of balanced budgets is still important because we have to demonstrate that it makes sense, a priori, to consider specific urban problems in isolation from the rest of transport services. Is there a general presumption for balanced budgets?

The reasons against any such presumption are well summarised by A.A. Walters(1). So far as roads are concerned, he argues, 'in principle (each road user) should pay for each journey an amount representing the value of the resources used up, including the rents of scarce facilities. For inter-city roads ..... the charge will be low, whereas for urban roads, the charge will be high. These prices reflect the net cost of the journies involved ... If these optimum prices are levied, the question whether and where there is a deficit or surplus turns primarily on the technological conditions and the investment policy pursued ... The requirement of covering costs (synonymous with 'budgetary balance') implies that returns to scale in road building are judged to be constant'. Typically, he argues, they are not.

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(1) In 'The Economics of Road User Charges: Int. Bank for Reconstruction and Development', John Hopkins Press, 1968. Esp. ch. IV., pp. 82-117.

Thus, at any one time there may be an accounting surplus over and above the costs of urban highways because of probable diseconomies of scale in urban road building and the level and growth of demands in relation to the discontinuities (of optimal investment). 'Uncongested inter-urban roads will certainly be in deficit on any of the numerous accounts and conventions customarily used.' The budget for roads overall, from these considerations of divergent conditions, will only be balanced (with optimal investment policies) quite fortuitously. Thus the requirement of 'covering the costs' in respect of one mode cannot be deduced by economic reasoning.

But suppose a competitive mode - e.g. rail - is required to 'cover its costs' perhaps for reasons of managerial or efficient control by the government and if it could succeed in so doing, should then roads be required to attempt to do likewise? "The short answer", says Professor Walters, is no. "A requirement of a balanced rail budget may give rise to rail fares and rates above costs for traffic where the railways have some competitive advantage, but ceteris paribus, some traffic would be lost to the roads which would be more cheaply carried by rail." Thus "it may be a good idea to raise road taxes above marginal cost charges on the highways to reallocate traffic to rail even at the expense of foregoing some road traffic altogether ... And it is conceivable that the requirement of a balanced budget (on roads) may result in taxes which are lower than the marginal cost charges (e.g. congested highways in densely populated areas)." So, in general, one cannot prescribe that costs should be covered at any level within a mode; what is prescribed depends on the circumstances, and in particular, the predicted effects of attempting to move towards or away from a "cover-cost" system of pricing.

Thus each case must be judged on its merits, or, as we would say, in a cost-benefit framework. Any such analysis would, as a minimum, consider the net gains and losses to prospective modal beneficiaries or losses, where significant; the change, if any on government account, and the broader resource costs or savings of the change. It should be noted here that, at some remove in the analysis, as a practical matter one must assume that conditions are broadly characterised by competitive relations in which budgeting equilibrium is necessarily involved. One cannot "correct" satisfactorily for all prices entering explicitly or implicitly into an analysis. So judgement must enter, as is common in all forms of cost-benefit analysis, about what should be specially treated.

The "proper" or "better" allocation of resources is not the only aim of governments, of course. So, in pursuing a cost-benefit approach, it is useful to begin by categorising possible reasons for subsidies, relating to various objectives. Not only, however, must a proposal for subsidy be related to objectives and specific circumstances, there must also, for rational decisions, be consideration of alternatives, to attempt to answer the question, is a subsidy necessary as well as sufficient to meet objectives? As we shall see, the logical scope for subsidy gets sharply diminished by these kinds of considerations. Also, as we have argued already, the method of subsidy payment is a most important consideration, having an effect both on the predicted cost benefit outcomes and on the relationship between the parties to the actual transactions which emerge.

IV. Specific bases for subsidy

The rather sparse literature on urban subsidies yields four kinds of justification, separable on terms of objectives and useful to analyse distinctly (though of course inter-related and not necessarily consistent with each other). In succeeding sections V - X we shall examine three of these, according the attention to each which their importance seems to warrant.

First, what should be termed macro-economic objectives, of high employment with stable prices, leading to a justification of subsidy via predicted effects on the wage/price spiral. Since this normally takes the form of support for an overall public transport subsidy we shall devote no time to it (in the main text), despite its historical and practical importance in the actual world of subsidisation. However, a discussion of some recent British experience is found at Appendix I.

Second, there are many arguments under the general head of improving economic efficiency at the transport industry level. The following main propositions have been entertained:

(a) (Some) forms of public transport are subject to economies of scale; a subsidy may be an appropriate form in which to bring charges (fares) close to current costs so that waste may be avoided, yet cash flow to the mode concerned maintained so that independent operation is possible.

(b) Some forms of public transport e.g. (certain bus services) may not be viable if one price is to be charged: if then separate prices to different customers are ruled out, but would be sufficient to cover costs were they allowed, subsidy may allow the service to be run, with net social benefit. (The demand curve for a service is postulated to lie outside the supply curve for the service).

(c) A subsidy may serve as a temporary alleviation to an otherwise loss making operator, leading to eventual operation at lower cost position. (A mixture of reasons are believed to be operating here; generally there is an analogy to an 'infant' industry argument for tariff protection).

(d) A form of public transport (in principle <u>any</u> form) may provide a customer with an option to purchase services even though it is seldom, or perhaps never, used by him. For various reasons, it is either impossibly costly, or very difficult, to organise cash payments for their service. (This is sometimes known as the 'stand-by' argument.)

(e) One mode might correctly be subsidised by another if peak/off peak differential charging for each mode is, for any reason, impossible. Costs and demands may vary as between modes at peak and off peak; switches of passengers can result in lower overall costs. (One or another variant of this argument has been often advanced to justify the subsidising of 'mass transportation' at the expense of vehicular traffic, to quote William Vickrey)(1).

(f) Some 'goods' or 'bads' are not traded on the market, notably aesthetic values such as the 'visual intrusion' of motor cars (as Professor Buchanan terms the parked vehicles in otherwise pleasing surroundings); or noise and fumes, costs imposed by modes not fully reflected in their normal accounting processes and therefore ignored in operation. Subsidies may correct for these deficiencies in, or redundancies of, production and consumption.

(g) One or more modes may be priced incorrectly, failing to reflect costs; compensating subsidies on one or more modes may

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(1) General and Specific Financing of Urban Services, AEA Readings in Welfare Economics. Eds. Arrow and Scitovsky, p. 577.

be indicated. This is, of course, potentially the most important 'efficiency' argument for subsidy, for it incorporates arguments directed at the lessening of road congestion, arguably the largest sources of losses in urban areas. Quite apart from this, however, it may be argued that if one mode is subsidised, a parallel subsidy is required on competitive modes and, in particular, to quote Fitch, the general rule should be followed that 'subsidies per ride for competing transportation modes should be approximately equal'(1). (This is to bring back, in a specific context, the argument already rejected at a general level by A.A. Walters.)

The list of possible situations inviting the notion that subsidy may be 'corrective' is of course endless. Thus one might find a justification in the (alleged) divergence between 'perceived' and 'behavioural' costs - i.e. the tendency of car owners in particular to be ignorant (in a systematic fashion) of their real outlays on car trips, and so to behave as if outlays were lower than they actually are, resulting in unintended overconsumption of car trips. (This divergence is part of the accepted 'hazards' in the cost benefit evaluation of urban road investments.) The evidence, however, does not appear to be strong enough to warrant special consideration as a basis for subsidy here.

More important perhaps is the argument for subsidy to augment or to support general urban planning policies. In so far as this has specific allocative meaning, it indicates that one way to compensate for the failure of the markets to provide the means for joint land use and transport economies is in effect to provide subsidies for development. Most 'planning' objectives are of course more correctly thought of as intervention to redistribute income in a particular way, and so fall into the next category to be discussed. But there can be joint products in planning of residences and transport which represent outputs otherwise unobtainable. An outstanding potential example known to the author is in the current planning of an underground railway in Hong Kong. Because of the peculiar topography, it is very likely that it would pay off quite spectacularly to combine a circular route with development of high density housing on the as yet

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(1) Hugh C. Fitch and Associates 'Urban Transportation and Public Policy', Chandler, 1964, p. 161.

underdeveloped parts of such a circle. Two-way peak operation on the circle at extremely high density could be feasible with this plan, offering economy of operation with sharply increased general accessibility. The market, though perhaps the world's most competitive, is unlikely to produce the desired result because, amongst other things, conventional transportation studies have faithfully reflected the present foci of traffic in forecasts. Thus, a government subsidy to underwrite development might seem useful.

One could conceive, therefore, of planners in this case of acquiring genuinely superior information and, more important, of there being prospectively large pay-offs to justify intervention. Such clear cut cases of joint effects ignored by market forces are probably rare, and certainly not well enough documented to form positive indications for action via subsidies. It is perhaps more correct to say that unless land use transport models are successfully developed to deal with extremely large changes relative to present land uses and transport they are unlikely to be able clearly to discern the benefits of radically different configurations. As things are, in most large Western cities the case for a transport subsidy to support superior land use planning, although possibly potentially important, is as yet unmakeable.

This is also not to deny that there may be many specific instances of intervention to promote complements to transport other than land use, to demote competitive factors, to 'correct' for suspected monopolistic or monopsonistic market effects, etc. All we can attempt here is to examine some of what seem to be the more important possibilities and these have been outlined. The list is influenced by the kinds of arguments likely to underlie practical subsidy proposals in the next few years(1).

The third type of justification for subsidy arises from <u>the intent to benefit a particular section or sections of the community</u>. As we have seen there has been a traditional concern in public transport, for example, for the aged and for the young, and these have frequently received specific subsidies. More generally, the widespread incidence of monopoly (franchised and licensed) operation has encouraged 'cross-subsidisation' from one

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(1) It has been drawn in the main from A.A. Walters, op. cit.; Meyer Kain and Wohl. The Urban Transportation Problem, H.U.P., 1965, pp. 341 ff; C.L. Fitch op. cit.; W. Vickery, op. cit.

part of public transport to another, in the sense of providing services at prices reflecting less than separable costs. Thus in the United Kingdom, this, once broadly justified as representing transfers from relatively rich urban dwellers to poorer urban or rural dwellers (or so it was believed - the evidence was rarely examined). Dwindling total profits have reduced the scope for this kind of cross-subsidisation, and it has become increasingly a subsidy to the poor from the almost, or quite as, poor, as public transport ridership has diminished, especially in the suburbs(1). We saw that attention now has shifted, especially in the United States, to subsidies designed to help the urban poor and ethnically deprived. (One form of subsidy recently received in this connection is the notion of free public transport, as for example, mooted in a Greater London Council green paper)(2).

Here again the possible justifications for subsidy are well-nigh endless. Thus, another traditional concern has been with the position of down-town shopping, commerce, etc., viewed as an economic collectivity, and threatened by declining public transport. The allocative efficiency aspect of this is, in the present state of land use and transportation studies, untestable. So far as it is a plea for special treatment for interest groups, it is likely to be successful only if identified with city-wide interests. And indeed a perhaps poorly focussed, but potent concern with the 'decline' of a given city will always occur, probably because of the political and managerial difficulties faced by a government of a city with a reducing population. For example, current discussions in the United Kingdom on the Greater London Development Plan reflect an anxiety that the metropolitan area is becoming 'unbalanced' in its population as decline proceeds - the middle-income technocrats, it is thought, are leaving in disproportionate numbers, with unclearly specified but thought-to-be-deleterious effects on the quality of life in London. In reality, such apprehensions are likely to motivate claims for transport subsidy more deeply than overt ambitions for identifiable members of the public. They may well be successful bases from which to

(1) The reduction in scope for cross subsidisation is dealt with in M.E. Beesley and J. Politi, A Study of Bus Company Profits, 1960-66, 'Economica', May 1969.

(2) The Future of London Transport: a paper for discussion: G.L.C., Oct. 1970, pp. 27-28.

claim assistance from a central Government. In this paper, however, we shall be concerned not with predicting the politics of inter-governmental transactions, but rather the uses of subsidy to help groups whose claim to assistance command very wide support, as the urban poor for example do.

The fourth type of justification for subsidy concerns innovation. The word used in its normal economic connotation, derived from Schumpeter - the marketing of new products or services, or the adoption of fresh ways of production or organisation of existing services. It presupposes in many cases research and development, and is tested by public exposure. The arguments in favour of its promotion and distinguishable in principle from the arguments about current efficiency or investment, which relate to the improvement of welfare with given existing resources.

Because of the element of research and development, it is true that the arguments for subsidy must in part hinge on such considerations as the technological spill-over to other sections of the economy, the opportunity cost of what is normally scarce and specialised manpower, as well as the predicted pay-off in transport terms. From a government's point of view, this aspect of innovation more usefully considered in a framework appropriate for the appraisal of research and development projects rather than the more conventional cost-benefit framework we have suggested as appropriate for analysing other aspects of subsidies.

We cannot comment on the very broad questions raised by government's proper role in the promotion of research and development. Our concern therefore will be with innovation, thus focussing on the marketing of new services. This may also be justified by the fact that research and development can often, and with small loss, be made organisationally separate from operation. Some more radical development, such as guidance systems for private cars require collective provision as well as publically supported research, and hardly raise the question of subsidies in the sense of the relationships between organisations postulated earlier.

Perhaps most importantly the problems besetting public transport in particular should not await upon potential technical break-throughs that may be over the horizon. Indeed, much of the potential relevant technical development is already known; so far as for example rationing of road space by road pricing or by sophisticated controls of the input flows to expressways, or priority access for public vehicles are concerned, the important impediments to adoption where this occurs seem to lie not in technical feasibility but rather in conflicting public objectives - e.g. a wish to avoid certain redistributive consequences of measures. An outstanding example of this is road (or 'congestion') pricing(1). So we may perhaps correctly concentrate on innovation as a process of the adaptation of known techniques to, and thus the creation of, new market opportunities. There can be little doubt of the relatively poor innovation record, in this sense, of urban public transport since the second world war (and this of course in part motivates the support of relevant research). The analysis of innovation in economics stresses market structure and the mobilisation of resources for this, and inducements and deterrents to the production of new products. In considering the relevance of subsidies in this context, then, we shall be concerned with the form of subsidies as they effect the conditions for promoting innovation, as we argued in the introduction. This is inseparable from some speculation about the desirability of changing the institutional conditions in which most urban public transport operators, and especially control over the entry of new enterprise.

V. The Efficiency Arguments: the Need for Cost Benefit Analysis

We now turn to consider, in the following sections, the more important bases for subsidy given in section IV. There, most attention will be given to economies of scale, the arguments involving congestion and those directed at helping specific populations. We examine first, however, an argument by Fitch et al concerning subsidies for competitive modes of transport(2). From the points made in section III we would not expect that the authors' dictum that 'subsidies per vide for competing modes should be approximately equal' could be generally supported, but their examples serve very well to illustrate the need to analyse propositions for subsidy in cost-benefit terms, and are interesting in themselves. Other arguments raised in Section IV are more conveniently treated after the main analysis.

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(1) In the United Kingdom, the techniques of road pricing are by now fairly well established as are the main economic consequences of its adoption. Deciding on who should gain or lose is the difficult political problem.

(2) In Urban Transport and Public Policy, op. cit., p. 161 ff.

Fitch et al present the following table representing five alternative subsidy arrangements; the third (equal subsidies per ride) is deemed to be superior (Table 1):

Table 1

Public Support of Competing Transportation Modes - Five Numerical Examples

1.	2. Subsidy $	3. Fare $	4. Assumed Travel Volumes, passengers	5. Total Transport Cost $	6. Total Fares $	7. Total Public Subsidy $
Fares at Cost						
Taxi	0	1:00	5,000	7,500	7,500	0
Bus	0	:25	10,000			
Subsidy to Costlier Mode						
Taxi	0.20	:80	7,000	9,000	7,600	1,400
Bus	0	25	8,000			
Equal Subsidies per ride						
Taxi	:20	.80	5,500	7,875	4,875	3,000
Bus	:20	.05	9,500			
Proportional Subsidies per ride						
Taxi	.20	.80	6,500	8,625	6,900	1,725
Bus	:05	.20	8,500			
Subsidy to cheaper mode						
Taxi	0	1.00	4,000	6,750	4,550	2,200
Bus	:20	.05	11,000			

Source: C.L. Fitch et al, op. cit., p. 164.

We should note several simplifying assumptions which in any realistic account of the options like those set out here would have to be considered more carefully. As Fitch et al point out, economies of scale are ignored, and it is assumed that the total number of trips by all modes is not affected by fare changes. This in turn means that a most important effect - that on private modes and, thus, effects on congestion, are also omitted; there is also no attempt to correct for effects on real incomes of riders of the various forms of subsidy. The assumptions about scale and congestion are acceptable for the purposes of illustration here; that on real income effects is usually made in any practical cost benefit analysis unless rather large changes are in prospect. That is, very often it is conventional and realistic to ignore the real income effects of subsidies; where, however, as for example, in analysing propositions for free public transport it is not - the effect on real incomes may be expected to be significant in terms of increasing trips both on public transport and on competitive modes(1).

But it will also be noticed from the figures in the table that the behavioural assumptions are not necessarily plausible. In the context of the decisions on modal split by a given total number of passengers, some curious effects are implied. One would suppose that the important factor would have been the comparative price-ratios of the modes before and after the application for subsidies. Before the changes, it is 4:1 as to taxis and buses. In option 4, with the same ratio the passengers are assumed to redistribute as to 1,500 extra to taxis. With option 3, the price ratio rises to 16:1 and still taxis are deemed to attract 500 more passengers from buses, and the ratio has to become 20:1 on option 5 for taxis to lose 1,000 passengers; whereas a shift in option 2, to 3.2:1 produces 2,000 extra taxi passengers. Such unlikely combinations underline the danger of a priori estimation and the need for actual measurements of cross-elasticities of demand between modes. However what concerns us immediately is the form of the argument, assuming the figures given.

The case for 3, equal absolute subsidies, is not made clear in the text. Certainly it is not self-evident from the Table. One possible interpretation might be to measure consumers' gains by the change from option 1, in column 6, and offset these by the corresponding changes in transport costs at column 5. But this

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(1) One example of such a proposition was mentioned above - that in a G.L.C. policy paper of The Future of London Transport. Another more detailed analysis - that of the Charles Rivers Associates - is discussed below in its appropriate context (see p. 32). Whilst both consider the implications of a fall in fares on public transport to 0 on public transport ridership, costs, etc., neither consider the (conceivably far from negligible) effects of higher real incomes on car use.

leaves the 'best' option as 5. The authors are perhaps confused over the position of consumers who move from one mode to another, for they speak of a 'loss' of forgone taxi rides for the 1,000 who transfer under option 5 from buses, valuing this 'loss' at 1,000 x 85 ¢, or $850(1). But so long as we assume that consumers are in equilibrium at the beginning, this cannot happen, of course. No one can be disadvantaged if he elects to change mode, accepting a price cut.

The subsidy 'required' for these options is at column 7. Fitch et al rightly point out that the subsidy should be distinguished because it requires sacrifices elsewhere - that it is highest with option 3 is, apparently, held to be unimportant, however. Clearly, in such an analysis, one should be prepared to distinguish between the options in terms of the impact of raising the subsidy. But one cannot rule out a priori <u>any</u> system of weighting of total costs, benefits, or subsidy, and differing weights might lead, of course, to different choices from 3. The comparisons should run in terms of change from the existing position and the effects on all parties explicitly, considered alongside others.

A more correct way to present the simple comparisons of gains or losses to the parties, or interests, involved here is, then, as follows: Customers of public transport may be distinguished; government, standing for tax raising, is a distinct interest; and resource costs, which stand, in a simplified way, for the opportunity cost of private consumption or investment foregone by expansion of transport services. These are useful categories for simple analysis, it could be said, because their interaction is small, and they give rise to substantially different problems of adjustment in the real world. We may agree to measure these by differences from 0 interference, or option 1. They may be represented respectively by the change in the position of consumers of transport from 1 to other options; similarly the 'public subsidy' of the table represents the government interest on behalf of taxpayers and 'total transportation costs' the interest of resource costs.

(1) P. 163, op. cit., for example, speaks of forgone taxi rides' in option 5 at $850. "This loss (sic.) in value to the riders (the 1,000 transferring) more than offsets the reduction in the community's transportation bill (compared with option 1) of $750."

It is impossible, from the data given, accurately to compute the change in the consumers' position. The correct way to do so is to analyse step by step for changes in prices on competitive modes and tracing the consequences in terms of benefits of movements along, and shifts of, demand curves. To do so involves making extra assumptions. We can, however, make an approximation from the data as given, by assuming that any customer of a mode gains an amount lying between 0 and the fare change of the mode to which he transfers, and computing the gain at ½ the fare change. Those staying on modes of origin gain the fare change of the mode of origin. (Essentially, if one argues that in Option 1 we have consumer equilibrium, then marginal consumers of buses and taxis are indifferent between the modes then. Marginal taxi riders value the extra convenience, etc., at 75 ¢.). The approximations are computed in Table 2(1). In Appendix 2 we present a calculation which does make some extra assumptions to enable theoretically more accurate estimates to be made. The results are very similar to those of Table 2.

From Table 2, option 3 can be said to be superior from the point of view of the consumers of both modes, viewed together. (This may have been in the authors' minds in envisaging an 'equal subsidies' rule). But a judgement must take into consideration the other effects of the changes. From Table 1, the 'best' option from the point of view of resource costs is No. 5, 'saving' $950 from the unchanged position option 1. The subsidy required is at a maximum with option 3, which also involves greater resource costs than does option 1. If the minimisation of subsidies is of some importance, even option 2 - though it involves the highest extra transport costs and lowest transport consumer gains, has some merits. All options, in fact, involve a trade-off between the 'interests'.

Analysis along these revised lines would have brought the decision to give subsidies in a recognisably similar framework to that of the analysis of urban transport investments. The plausibility of the behavioural assumptions is of importance, but the first requirement is to differentiate clearly the affected parties and then proceed to estimation. And the answer to the question of which form of application of subsidy is superior - absolute

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(1) Overleaf.

Table 2

	Option 2		Option 3		Option 4		Option 5	
	Existing	Diverted	Existing	Diverted	Existing	Diverted	Existing	Diverted
Taxi riders	5,000	2,000	5,000	500	5,000	1,500	4,000	
Bus riders	8,000	–	9,500	–	8,500	–	10,000	1,000
Gains $:								
Taxi	.20	.10	.20	.10	.20	.10		
Bus			.20		.05		20	10
Total Gain: $								
Taxi	1,000	200	1,000	50	1,000	150	0	0
Bus	0	0	1,900	0	425	0	2,000	100
Grand Total $	1,200		2,950		1,575		2,100	

equality, proportionality, etc. - must similarly depend on the facts of the case presented in the appropriate framework. A similar need is seen in the next section, which presents another argument for subsidy, which has had considerable currency.

VI. An argument from peak/off peak travel

In "General and specific financing of urban services", reprinted recently(1), W. Vickery writes that a "basic argument (for subsidy between one mode and another) can be obtained from the following example, which illustrates how far off the 'every tub on its own bottom' philosophy can get when misapplied." He supposes a facility of Type M, which "attracts rush hour and non-rush hour passengers in the ratio of 1 to 4, costing $1 for every rush hour passenger provided for and 0.20 for each non-rush hour passenger." An alternative facility T costs $.75 and $.15 respectively, a uniform 25 per cent difference, but attracts passengers only in the ratio of 1:1 for rush hours and non-rush hours. As he also says "if for T we read suburban rail service and for the M facility we read streets and highways, the correspondence with typical facts is reasonably close." In those circumstances, with a separate break-even and common peak and non-peak charges as constraints on the modes, the break even charge for M is ($1.00 + 4 x $.20) ÷ 5, = $.36; for facility T the break-even fare is ($0.75 + $0.15) ÷ 2 = $.45. So the passenger is offered a 9 ¢ fare differential in favour of M on peak and in off-peak alike; whereas the marginal cost on T is lower in both cases. (We are in a world with constant returns to scale). So some redistribution of passengers to T is indicated. Vickery remarks that if peak, off peak pricing differentiation is ruled out, 'the next best thing would be to reverse the relationship between the charges', giving a fare to T of 35 ¢, a charge to M of 45 ¢, "resulting in a subsidy of about 25 per cent to T from excess revenues of M". "Thus in these is an even stronger case than would exist otherwise for subsidising mass transit at the expense of vehicular traffic."

The argument really turns first on the very acceptable proposition that peak and non-peak travellers are in virtually separate markets, and second on the assumption that travellers

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(1) A.E.A. Readings in Welfare Economics, pp. 576 ff.

can be diverted from M to T at both peak and off peak at the margin with a gain from resource savings. But that a fare change via subsidy would help this to be realised is in doubt when the postulated situation is examined more closely.

First, we must suppose that some initial equilibrium between T and M exists such that passengers are found on each at peak and off peak; otherwise we cannot link the example to "typical facts" - for one mode (M) would exclude the other. In this case, the initial position for the marginal peak traveller on M is that, with a 9 ¢ difference, he is indifferent between the modes: thus he must value the advantages to be gained from choosing T at a maximum of 9 ¢'s worth of benefit (perhaps T is more comfortable or takes less time). If he then shifts to T, his maximum gain in benefit is 9 ¢. Others, intramarginally, who also shift, gain less. But this shift is accompanied by a decrease of resource costs by 25 ¢, by definition; so, in simple terms, there is a case from considerations of efficiency for this shift. (The advantage will of course decrease for intramarginal users of M). For the off-peak traveller on M, by similar reasoning, the maximum benefit of a shift to T is 9 ¢; but here a resource saving from the shift would only be 5 ¢. This shift is allocatively perverse, because losses in benefit outweigh resource cost gains.

So the postulated average change in fares, reversing the prices for M and T, will indeed be beneficial, net, on peak, - but not off-peak. Thus the 'corrective action' is indeed a very inferior solution to peak pricing, and in fact <u>worsens</u> allocation off-peak. The upshot is that <u>if</u> subsidies are to be used in a situation like this, the gains and losses must be separately computed for the different markets. The peak gains <u>may</u> offset the off-peak losses, or they may not. Alternatively, subsidies might be devised that in effect offer a differential inducement in the off-peak and the on-peak. But if indeed a subsidy's differential effects must be disguised, it will have to take an indirect form such as payments for equipment used in T's peak, thus for example, inducing shifts via changes in comfort. But this of course is a very round about way of solving the problem posed by a pricing constraint - far better, one would have thought, to attack the problem directly. Of course, in a realistic situation, an additional justification for the policy Vickery advocates enters - a reason for weighing peak gains to T exceptionally highly, such as congestion costs not reflected in M's prices. This requires a more thorough going analysis, and we come to it later. Another moral, to be learned from this example again, is that the demand conditions on modes must be clearly specified, otherwise misleading inferences for costs and benefits may be drawn.

VII. Economies of scale in urban transport

Meyer Kain and Wohl assert: "the most solidly justifiable argument for subsidies is that urban transportation is characterised by increasing return as scale increases, and that only by subsidisation can the consuming public fully reap the benefits of these increasing returns". (op. cit., p. 341). This opinion has to be accorded respect, if only because these authors make the most ambitious comparisons of alternative system costs in urban transport to appear to that date (1965) and indeed, so far as I am aware, since. Now clearly, as the authors recognise, the evaluation of this opinion depends critically on issues such as what alternative pricing policies are available, for example, possibilities of substituting for a single price or fare on a mode various schemes designed to raise the required revenue, such as 'club' subscriptions and fare differentiations of which there are of course many kinds. Also relevant would be such questions as the terms on which the subsidies are raised, whether the case is reinforced by congestion relief, on alternative modes, etc. etc. But whether this depth of analysis is useful depends on the scope for realising economies of scale via subsidy. This we may examine through considering the authors' own data.

First, the methods used to generate information about the relation between output (passenger volume) and costs was to select several different modes (rail rapid transit, auto, and bus), analysing for a variety of situations of collection at residences, line haul, and downtown distribution, and allowing for a variety of densities for collecting areas and conditions en route, for a number of distances for line haul, and for various downtown distribution lengths. It concentrates on rush-hour conditions; broadly the method was to compute the total costs of inputs to a system built anew, except for the use, in some options, of existing down-town streets. The option quoted seems to be based on a selection of the more important options discussed at pp. 291 following. The authors are understandably reluctant to aggregate costs to systems, and stress the variety of possibilities. But they do present total costs for 5 systems - (a) line haul transit with downtown subway and separate feeder bus service for residential collection; (b) line haul rail transit with downtown subway and park-and-ride service for residential collection; (c) line haul bus transit on exclusive rights of way with integrated, continuous service residential collection and downtown distribution on surface streets; (d) line haul bus transit on exclusive rights of way with integrated, continuous service on surface streets in residential collection and in exclusive bus subways in downtown distribution; (e) auto service in exclusive rights-of-way for the line haul and on the surface streets within residential and downtown areas(1).

As will be seen from these descriptions, the focus is on the suburb to centre peak movement and thus on quantities of movements that favour large systems. The "economies of scale" that we shall examine are, where present, due to indivisibilities of construction in the main. We may be fairly sure that, of all urban transport situations, those represented here maximise the chances of encountering economies of scale. The method is the acceptable one (for the specified purpose) of engineering-cum-economic computations of costs for different volumes given known technology, and building for the most part from scratch. (Other methods of cost estimation such as cross-section studies, would have been impracticable). Travellers' time values are omitted from the computations.

Each of the 5 'modes' is presented as the variation in cost per passenger trip, between residence and downtown as a function of (one way) hourly passenger volume per 'corridor' at maximum load point. (This last condition again presumably maximises the chances of discovering economies of scale). Four sets of functions are presented, representing essentially a 10 mile line haul, with variations in the length of down-town distribution and the conditions of residential density along corridors. Higher en route densities raise average costs substantially, and increase slightly the proportionate effect of 'economies of scale', as measured by the average change in costs as passenger volume increases. So we may usefully concentrate on this kind of option; doubling the downtown distribution length from 2-4 miles (thus postulating a very large central area) again raises costs but,

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(1) Op. cit. pp. 299-300.

over the critical range we shall establish, diminishes, if anything, the proportionate effect of scale. Our comments thus run in terms of the 2 mile version (Figure 54 reproduced here as Diagram 1)(1).

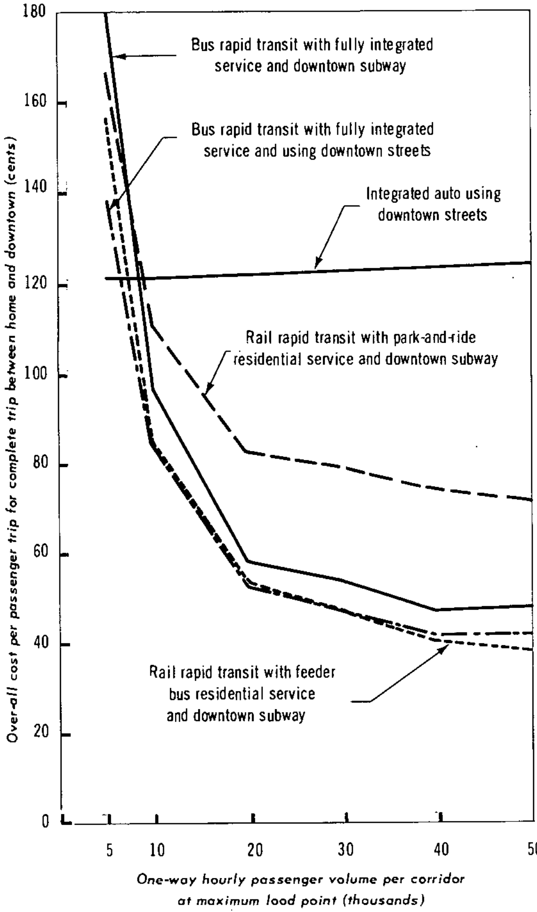
First, the omission of passengers' time from costs. There is some evidence, but very little, that time spent may increase with passenger volume under the stated conditions. This is not sufficient to disturb the comparisons. Second, it must be remembered that essentially these date concern options to build ab ovo. They are <u>not</u> adaptations of existing rights of way, which might be expected to lead to increasing costs with scale (as complications and costs of land purchase rise, connection costs to existing systems rise, etc.), but, so far as line haul especially is concerned, represent the insertion of completely self-contained movements. So no congestion builds up in the downtown system, for example, even for autos running on surface, as numbers increase. Again, the conditions postulated tend to favour the discovery of economies of scale. (So also does the assumption that there is no factor cost variance with scale of building).

In these conditions then, it is found that for all systems except auto, which as can be seen, is subject to slightly increasing costs with scale, enjoy substantial economies. Average costs per passenger in general at least halve over the 5-10 to 50,000 passenger range. However, if the choice is between systems, the <u>existence</u> of scales are irrelevant if a cheaper mode exists. Below about 10,000 passengers, auto is cheaper. Hence the critical range begins there. <u>If</u> one can then postulate an increase in volume, the average costs on modes other than auto will decrease. But potential corridor volumes vary immensely with cities. As we can see from the authors' table 20, page 86, only one city (New York) in the United States experiences an average corridor volume at above 60,000. There are no cities between 40,000 and 60,000, only 1 between 30,000 and 40,000, 3 between 20 and 30,000 and a further 9 between 9,000 and 20,000. Over 20,000, as the figure shows, the dominant low cost modes show relatively little gain to scale. If we were to be concerned, therefore, with a city like Chicago, we might expect to be able to get a small gain by say increasing available custom from 20-30,000. Over that range

(1) Overleaf.

Figure 54

OVER-ALL HOME-DOWNTOWN PASSENGER-TRIP COSTS FOR HIGH RESIDENTIAL DENSITY ALONG CORRIDOR, HOURLY DOWNTOWN PASSENGER-TRIP ORIGINATIONS OF TEN PER BLOCK AT THE HOME END. 10-MILE LINE-HAUL FACILITY, AND 2-MILE DOWNTOWN DISTRIBUTION SYSTEM ROUTE LENGTH



Source : Meyer, Kain & Wohl. op. cit. p. 302.

we might expect about an 8 per cent reduction in average costs per passenger - hardly a spectacular gain. For the 9 other cities and Chicago (New York is clearly an exception with very special problems of access to downtown) there might be substantial gains over the 10-20,000 range. However, the number of cities in which there is a possibility to achieve this is so small as to limit severely the scope of the author's remark that 'the empirical validity of increasing returns seems undeniable on the basis of the cost analyses' (p. 341).

The arguments here should not, of course, be confused with the case for subsidy to fill excess capacity in public transport once invested in. This has to be argued on its own merits. The appropriate decision situation here is one in which the government is deciding on the aid to the construction of new facilities. In that case, too, the question is not so much the potential existence of scale economies, but the question of how the requisite volume is to be achieved, whether with subsidy or not. To double corridor volume, for example, means substantial increases in the collection and distribution mechanisms, especially at the residence end. These are reflected in the costs, and account for the sharp tapering off of gains with scale. But if the option for travel is auto, as it usually is, then a large inducement, increasing with volume, is needed. Even if one ignores times of travel, convenience, etc., and is planning auto versus rapid transit alternatives, then as the figure shows, the differences between auto and rapid transit costs widens fast between 10 and 20,000 corridor volumes and tails off thereafter. If one has a problem of attraction to transit (and all such systems appear to have one) then one might view this differential as a minimum measure of the subsidy needed to overcome auto's relative attraction. If so, then it is clear that the problem of overcoming the difference at most levels is much more important than the effect of scale economies, except over the 10-20,000 passenger range. The absolute differences between the modes swamp the scale economies thereafter. So from this point of view again, the scope for subsidy to reap economies of scale is limited to a rarely encountered situation. Similarly, there are severe limits to the effects of scale economies for increasing the scale of rapid transit of given capacity by extension, for example, to outlying suburbs. The predicted passenger use drops off rapidly as lines push out further as recent experience in London in comparing differing extensions of underground lines has shown. And even if successful, increasing outer market areas for given capacities, entails reduction in service quality for passengers from inner zones.

In the exceptional cases where subsidy to gain economies of scale might be contemplated, the problem of securing volume is probably so great as to swamp the choice between using various devices for pricing for recovery of costs and, alternatively, of using subsidies. Over the critical volumes considered here, very large inducements would have to be made to make public transport attractive: the famous conclusion of Moses and Williamson that negative prices would have to be charged to shift substantial volumes to rapid transit has considerable substance in this limited context. The value of travel time was exaggerated in that study, true, if the many subsequent studies of time value are to be believed(1). But the quantities involved in the present comparisons - one has to contemplate doubling of ridership - are so large as to make it credible that subsidy would be inevitable if the required volume is to be forthcoming. The gains from scale, if they are to be realised, will be very costly in terms of required subsidy.

VIII. Urban Congestion and the Cost Benefit Analysis of Subsidies

(a) Measuring the effects of congestion

In contrast to arguments deriving from scale economies, those involving congestion stem from conditions where investment is not a variable. The total urban infrastructure is given; the potential gains from subsidy arise from more efficient use of the existing transport networks. This is a useful limiting case to consider, either because in many cities either a severe constraint on investment is effective (e.g. the wish to leave city centres in particular physically much as they are now) or because any substantial change in that infrastructure will take many years to accomplish, thus posing a major problem of current efficiency

(1) Moses and Williamson: Journal of Political Economy 1963, Vol. 71, 'Value of Time, choice of mode, and the subsidy issue in urban transportation', pp. 5-27. These authors assumed that journey to work time was valued at the average wage or salary level. Subsequent empirical studies give values ranging from 25-40 per cent of that level. Compare: Harrison and Quarmby: E.C.M.T. Round Table on the Values of Time.

over a longish period. That any cost-benefit appraisal of subsidies for public transport is likely to include effects on congestion as a large but varying item according to the specific circumstances is suggested by the estimates that have been made of the gains from various forms of restraint of private car travel in urban cities. These include calculation of the benefits from (a) instituting road pricing(1), (b) instituting other forms of private traffic restraint, such as licences-to-enter and parking(2), (c) transferring passengers in central London from cars to various forms of bus services(3), (d) the cost-benefit studies of urban infrastructure(4) and alternative rail, bus and tube services to Heathrow airport(5). Curiously, in an important study estimating the benefits and costs of a free transit service for Boston, the Charles River Associates mention, but they do not compute for, major road decongestion effects - i.e. the gains in time and operating costs which accrue to road users not diverted to free transit as a result of those which do transfer(6). In what follows, while reporting empirical work, we shall be concerned mainly to point out the essential steps in an effective analysis, and what appear to be the main requirements for progress in making data available.

Now, from the point of view of a government deciding upon subsidies or alternatives, it would of course be very useful to compare these differing approaches, bring them to a standardised base in terms of predicted decongestion effects in differing conditions of traffic flow, time of day, modal distribution, etc. Unfortunately this is quite impossible to do without a large scale research effort since each study proceeded from a different set of assumptions and was conducted at a different level of

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(1) Compare the work following the Smeed Committee's Road Pricing.

(2) Compare J.M. Thomson: An Evaluation of Two Proposals for Traffic Restraint in London. Journal of Royal Statistical Soc. Series A (General), Vol. 130, part. 31967, pp. 327-377.

(3) Compare D.J. Lyons Bus Travel in Town Centres, Traffic Engineering and Control, 1969 ii (i) 20-23.

(4) e.g. Studies of London Transport tube extensions for the Victoria Line study onwards.

(5) Report of a Study of Rail Links with Heathrow Airport, H.M.S.O., 1970.

(6) 'An Evaluation of Free Transit Service', Charles River Assoc., Inc. Cambs. Mass., Aug. 1968, pp. 146-169.

aggregation (some were concerned with the whole of a central area, some with those parts of it affected by specific services, etc.). But, in any case, useful as such a reconciliation might be, a government would still be faced with the general problem of discussing where intervention in any form, subsidy or others would best pay off. The initiation by the operators of services for which financial help is sought, and then subjecting only them to cost-benefit analysis is probably not sufficient; there is of course no guarantee that existing services contain the 'best' candidates from an overall viewpoint.

We shall have more to say on this question of initiation later when considering innovation, but meanwhile it should be noted that there is, in principle, a need for studies of existing networks to reveal the most critical paths and nodes for relief. There may not be the obvious (i.e. the already apparently worst) bottlenecks, for a prediction of spatial congestion under reduced flow conditions is required. Essentially, we want to predict reactions of trip making changes associated with a change to less congested situations. The effect of a reduction in congestion has traditionally been looked at either by calculating for generalised speed/flow relationships on links of a network or for classes of road widths, or, more recently in the United Kingdom, by computing changes in conditions at overloaded junctions(1). Both computations depend on an assumed reduction in some total vehicle mileage, and do not therefore lead back directly to predictions about expected journeys - and substitution for them - under more free running conditions. So one important reason why prediction is so difficult now is the paucity of material on point-to-point journeys in large urban areas, classified in sufficient detail by overall mode or modes route, time of day, journey purpose, time cost, cash outlay, etc. One way of looking at the general problem is to say that one should seek to discover the distribution of prices which would obtain with, and thus, in congested spots, the rents implied by an optimal price system on the transport networks(2). The base of the calculation must be the journey, as the decision element.

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(1) As in the work to be mentioned below (Appendix J) Transport in London Cmnd. 3686, July 1968.

(2) Some of the practical difficulties of doing this in respect of road pricing were discussed in my paper to this conference 4 years ago. One can unfortunately report little progress since, though one remains hopeful!

Unless and until such general guidance is forthcoming, the government' will have to decide on the merits of more or less ad hoc proposals. Let us follow through this decision process as it might now feasibly occur. The first important task is for the government to decide upon the level of service (number of passenger miles) which might be justified by intervention of some kind. Two recent examples of this kind of calculation have occurred in the United Kingdom - the second more directly relevant. The first was the calculation in 'Transport in London' - a Government statement of policy, inter alia, on the consequences of allowing a deficit to be a more permanent feature of London Transport's finances. The calculation concerned the annual value of time lost via extra road congestion for differing levels of transfer of trips from buses to cars. Broadly it was thought that, for a range of extra car trips from 15 million to 60 million a year, there would be an extra cost (i.e. imposed on existing road users) over that range of about 15/- to £1 per car trip, in 1966 prices. Because little reliance could then be placed on the calculations, they probably did not feature very importantly in the decision, at that time concerned principally with the financial terms on which responsibility for the London Transport Board, a nationalised concern, could be transferred to the Greater London Council (Metropolitan London's 'government'). Nevertheless, the finding on congestion costs may have helped the decision, arrived at on other grounds, to relieve L.T.B. of much of the interest charges arising from part indebtedness to the Treasury as a condition of takeover(1). It did, however, perhaps give some notion of broad orders of magnitude - different, to be sure, from those implied by the works cited earlier - but still indicating a potentially large decongestion element in a cost-benefit analysis.

A direct attempt to quantify the social costs and benefits of withdrawing a bus service in London was made in 1970 in the N.B.P.I. report on London Transport Fares, Cmnd. 4540(2). This was a calculation done by L.T.B. as an example for submission to the P.I.B., it perhaps fairly represents the current state of the

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(1) 'Transport in London' op. cit. The London Transport Board, transferred to the G.L.C. under the 1969 Act, is now called The London Transport Executive L.T.E.

(2) National Board for Prices and Incomes Report No. 159, H.M.S.O., Nov. 1970.

art. It concerned the proposed withdrawal of a peripheral section of a bus route linking a residential area with a shopping centre and railway station. The costs and benefits of withdrawal are calculated for six interests: London Transport; British Railways; Local authorities (negligibly affected); central government representing taxpayers; London Transport users; and road infrastructure users. Appendix 3 to this paper gives the matrix of results. By far the most important item, in a total effect, summing across all interests, of £87,000 a year additional net resource cost, was an item for £120,000 a year cost for extra congestion predicted to be experienced on road infrastructure. On rather rough assumptions, one can calculate that this may have been equivalent to some 2/- (10 new pence) per displaced bus passenger trip at 1968 prices. Most of this was no doubt due to an unspecified number of substituted car trips, which would of course each imply a higher congestion cost per trip than their bus equivalents. Thus, the congestion costs were substantial - the average L.T.E. bus passenger trip at the time cost the passenger 8 d. (3.3 new pence) in fares.

There is still great uncertainty about these figures, of course. The higher figure for the effect of congestion quoted in the previous paragraph, at 15/- (75 new pence) to £1 per trip, compared with 2/- (10 new pence) here, must be due to some extent to the fact that a different area of London was concerned. But the assumption in the first calculation was extreme. No decongestion effects were counted for suburbs - only those for central areas of the peripheral 'glue-pot' ring were allowed to enter the sums. The most important areas to clarify in these calculations are therefore the assumptions about demand for buses, a clarification which is also of great significance for the subsequent question, should subsidy and other means be selected for support if it is to be given?

We are concerned here with several measures of demand - the price elasticity for the mode in question, say buses; its time elasticity; the price cross-elasticities between the mode and others, and the 'time' cross-elasticities. The price elasticity gives predictions about the total change in passengers due to a fare change; the time elasticity similarly for differences in point to point times for travel; and the cross-elasticities measure specific effects upon competing modes of a change in the price or time of the 'subject' mode. One could, of course, in principle distinguish as many categories of elasticity as are relevant for predicting actual behaviour (e.g. comfort, conveniences other than time, etc.) and these can only emerge from specific study; examples of actual price and time elasticities are given later. Particularly important in this area is the status of the motor car as an alternative to public transport - the conventional categories of price, meaning cash outlays, and time spent, may be insufficient to delineate demand for the car because of, complications arising from the household competition for use of cars (more drivers per household than cars available) and the linked use of cars (e.g. for a day's trips from a first destination). Looked at in another way, the opportunity cost of cars is likely to be extremely variable from household to household depending on what alternative uses are forgone; and certainly more variable than for most public transport options. It is difficult therefore to pin down the car option in measured car 'costs' such as petrol and other cash outlays - or indeed time spent in the car journey(1). Also, cross-elasticities must be distinguished from total price and time elasticities precisely because of measuring congestion effects - both the subtraction from other modes and the total 'subject' mode carrying of passengers are relevant to the predicted final state of congestion. (Thus it matters greatly in London whether the total change in predicted bus passengers affects tube or car use, and in what proportions).

The cost benefit study reported here relied on implicit measures of these effects; predictions of the transfers between modes was, by and large, left to the 'hunch' of experienced L.T. executives. This was very sensible under the circumstances. It seems likely, however, that a rather 'optimistic' view of linked trips was taken for example - i.e. trips originating by bus and continued to the central area on train. It was held that some of these at least, would be substituted for by complete car trips to town if the bus to the suburban station was withdrawn. This kind of assertion is critical, of course, because it is the relatively long suburban - originally downtown trip which 'causes' or encounters much of the congested conditions; and might well have

(1) Modal split studies relying on imputer average car 'costs' e.g. out of pocket expenses, are particularly suspect for these reasons.

accounted for much of the recorded 'social loss'. So, again, progress towards consistent and accurate computation of these losses depends on deeper study of mode (and trip-end) substitution.

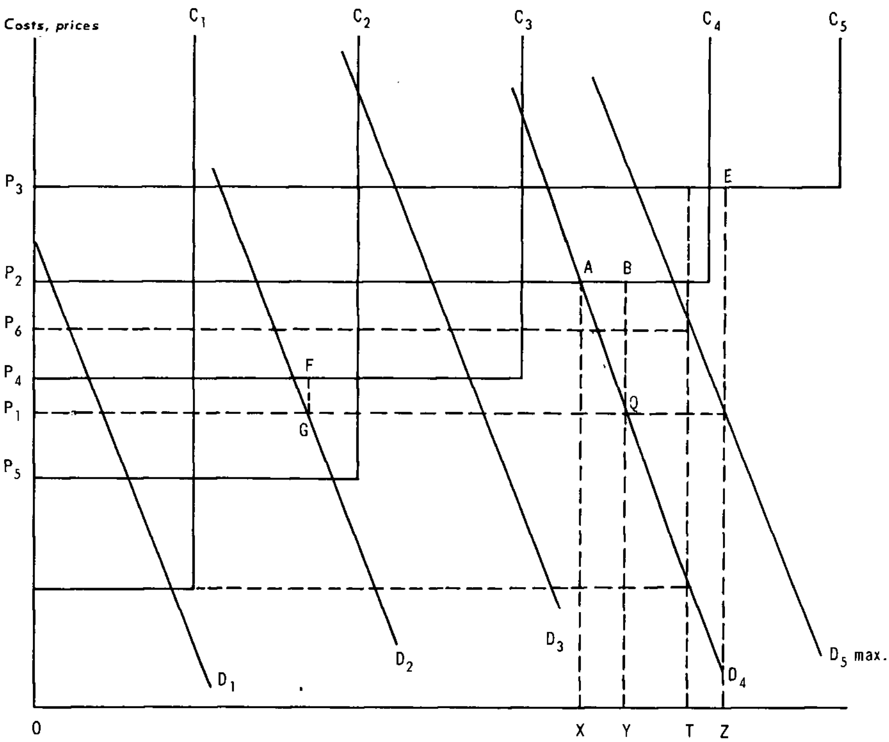
(b) The analysis of alternatives: a bus service example

Assuming, therefore, that the external benefits and costs of intervention in services can be evaluated at least to an acceptable level of confidence, it is instructive to consider how, in detail, one might decide upon the level of support if any. As an example, a bus service will be taken. 'Support' means deciding upon the level of fare; how that level should be achieved, i.e. the form of the subsidy, if any, is discussed later though we shall provisionally call it 'subsidy' here. We are essentially interested in distinguishing the following effects: the quantity of service provided (which effects the external benefits and costs); the gains and losses to customers; the amount of support; and the level of costs (real resources) implied. As foreshadowed earlier, trade-offs between the quantities are to be expected. A not-untypical bus service situation in an urban area may be represented in the diagram:

(See over for diagram 2).

We suppose a bus service which may vary in its service characteristics, represented in the provision of different numbers of buses to serve a route in a given time period; say an hour, or perhaps half-hour. The costs associated with one, two and up to 5 buses are denoted by C_1 - C_5. Costs are rising at the margin in two senses, as is realistic for urban conditions; first, because for each bus, as the number of passengers loaded increases, at a certain point delays of loading, etc., cause costs to rise sharply for that bus. For convenience of exposition only, each C curve is thus drawn with a vertical stretch at the point of overload. Costs are also rising as buses are added, because extra labour is difficult to hire, and for a company (or the industry) as a whole, increasing numbers of passengers can only be found on certain, not all, routes and at certain times. This, with union rules about rest periods, broken shifts, etc., means additional costs. (The analysis would not be substantially changed in principle by having constant average costs, or indeed falling costs, though the trade-off weights of course would). Normal profits are included in costs.

Diagram 2



Bus Frequency and Number of trips made

Demand is also supposed to vary with frequency, because more buses per hour represents less waiting, greater planning certainty, etc. Because a demand curve is normally drawn up with a fixed standard of quality in mind, we draw $D_1 \ldots\ldots D_5$ to represent demand for different qualities of service. The spacing of them in relation to one another represents the common view that demand is proportionally higher as service frequency increases from zero, but is subject to some limit, i.e. there is a maximum frequency beyond which extra demand cannot be realised at a positive price. This condition occurs at D_5 (max.) in our representation. The slopes of the D_6 are determined by alternative opportunities, and modes, for trip-making.

We may suppose that, under these conditions, the current fare is at P_1, 4 buses per period are in service and the passengers are OY. A loss of P_1P_2BQ is experienced, and the operator applies for financial support. We know that a given loss of passengers means a given external effect, especially in congestion. But the number of buses also has an effect on congestion (perhaps a second-order one) which we should not in principle ignore. If the facts are known to the government as they are presented, then it can contemplate, as examples, the following options, all of which leave the operator with the benefit of becoming commercially viable in respect of the services in question.

1. It could 'allow' fares to clear the market at OX, with four buses per period. This 'loses' XY passengers and thus the consequent congestion effect is positive; the support needed is zero; the subsidy is zero, and bus resource costs are less by ABYX. Bus customers lose a benefit of P_1QAP_2.

2. It could 'allow' greater reductions, with market clearing fares for D_3, D_2, D_1, with increasing losses in terms of passenger reduction, but with offsets to the consequences of this in congestion terms because of bus withdrawals. The 'support' is zero, and increasingly large bus resource cost savings are made as buses are withdrawn. Bus customers lose amounts measured by the changes in the areas under the respective demand curves bounded by the fares actually paid.

3. It could cause, by a subsidy from some source, the 'output' of OY, with four buses, to be maintained, by granting a subsidy of P_1QBP_2. There would be zero passenger loss,

and thus zero congestion or bus resource cost changes. Bus customers experience no change. There are no direct allocative effects; the major change is to distribute income from subsidy-givers to the bus operators.

4. It could offer in the conditions depicted in the diagram, a bigger subsidy on condition that an extra bus per period was put in service. This would increase the quantity of passengers carried, say, to OZ, and would increase bus resource cost outlays to cost level C_5, at E. The congestion gains from increased passengers are offset to the extent of an extra bus on the route. Bus customers gain by amounts analogous to those lost in 2.

5. For smaller subsidies than either 3 or 4, we could allow buses to be taken off the route, but with smaller losses of passengers than in 2. Bus resource costs are saved; customers again lose surplus.

In general, then, the 'gains' to increasing a subsidy are limited by the position of D_5, rising resource costs, and secondary congestion effects via the increase on bus mileage. The 'gains' to allowing market-clearing pricing are limited by increasing net congestion and bus customer losses.

It is sometimes argued that a 'subsidy' is justified by that 'fact' that withdrawals of service make for a cumulative deterioration in welfare via increasing losses of passengers. This can only happen, in our analysis, if net congestion and bus passenger losses are sufficient to offset resource cost gains, though of course alternative weightings for the various interests in the calculation are possible. It is true, however, that in the conditions postulated, the effectiveness of the subsidy (in terms of congestion losses avoided), is decreasing at the margin as the bus service decreases, and thus, other things being equal, the case for subsidy to prevent decline is stronger at levels of service near the maximum, though the benefits for increasing subsidy near that point are of course much less evident(1). Clearly

(1) Congestion losses associated with losses of passengers may, however, be increasing - i.e. the congestion loss per passenger may increase at the margin. This is a possibility which needs specific investigation - current measurements of congestion effects are not sufficiently discriminating to test this at the bus service level.

also, it may turn out that a move to a market clearing price like P_2A on D_4 may be preferable to a subsidy like p_1P_4 for a service D_2, from the given starting position: 'too small' a subsidy will lead to the loss of relatively large amounts of passengers, and the resource cost savings may not be enough to compensate for this (again, we ignore weighting factors)(1).

Arguing from the same initial position, an alternative assumption of constant average costs, as buses are added, would modify the picture in the following main ways: the market 'clearing' option becomes relatively less attractive for the movements involving losses of passengers (a given subsidy 'buys' more retained passengers and there is a smaller effect via bus resource gains from lower 'output'). An increased subsidy to increase service offered is also relatively more attractive in these conditions. Compared, therefore, with the increasing costs case, one might expect (unsurprisingly) a net preference for a larger subsidy, still limited, however, at some point by the diminishing absolute demand as bus services increase.

The further alternative of decreasing costs is not likely to be met with in urban bus operation except in the very limited sense of empty seats with number of buses given. As far as increasing average bus occupancy with a given service frequency is concerned, this can be analysed in terms of the diagram by imaging movements along the respective D curves. But such is the importance of service frequency that support would hardly be worth considering just to fill a given bus.

One important comparison brought out by the diagram is the quantity of passenger trips intervention can 'buy' for a given service compared with those 'bought' for a change in service levels (the resource cost, etc., terms would also enter the cost benefit analysis of course). Thus, again starting from OY (on D_4) a movement to OT for example could be accomplished by subsidising D_4 to the extent of P_5P_2: but a better 'buy' may well be a subsidy of P_3P_6 for D_5. Which sort of move pays off best will turn on the elasticity of demand for a given service level relative to the shift of demand between service levels. There are obvious limits to this trade-off: on the one hand, rapidly rising costs

(1) We should note that further bus resource costs may also be saved if fare collection is abandoned.

will limit the pay-off to a given service at some level i.e. one encounters the vertical stretch of the cost curve; and at a limit like D_5, by definition, the only way of increasing passengers (and gains to them) is by movement down the D_5 curve.

The impression given by such attempts that have been made to measure the elasticity of bus demand is that it is quite low; they have never to my knowledge exceeded 0.6, and some recent measurements are quoted below. Such estimates are extremely crude, of course, and often computed for large aggregate of services. They may be said at best to represent some weighted average of the D curves of the diagram; but certainly incline one to scepticism about the pay-off to intervention to fill given capacities. The analysis points up an urgent need - again to my knowledge nowhere attempted explicitly - to estimate demands and corresponding elasticities for different service levels. This implies a very tricky exercise in standardising for other factors. An unhappy feature of many existing bus information systems is that the amount of knowledge generated about customers has decreased as mechanisation of fares and the spread of single fares has proceeded. Much less can be learned than formerly from tickets issued, for example. Fortunately, there are signs in the United Kingdom at least, that the analysis of bus demands, involving special surveys, is beginning to become a serious part of the research programmes of large operators.

Also, explicit recognition of the shifts in demand associated with the policy options discussed brings some difficulties of computing losses and gains to bus customers. For example, while in option 1 of page 38 measuring the consumer surplus lost does not pose unusual difficulties, in option 2 it does, for in principle we require data on very considerable portions of the demand curves. No doubt, however, suitable approximations could be devised given information even covering a rather small range of relevant demands. The important point about improving information for cost-benefit analysis is to keep a balance between the quality of information for each important interest in the analysis. Too much concern with demands could be disfunctional, if it implies neglect of other important elements. Such an imbalance has often marred cost-benefit exercises in the past.

(c) Alternative forms of intervention: the role of subsidy

Let us suppose, then, that a cost-benefit analysis along the above lines has been done, so far as data and costs of calculation permit. (We may also suppose that so far as is practicable effects on externalities such as noise, fumes, visual intrusion, etc., have been entered into the calculus). We wish now to consider what form intervention should take, if there appears to be a potential net benefit from doing so.

Certain possible forms of intervention which logically should be considered here lie outside the scope of detailed comment in this paper. Thus a government could aim to work upon the underlying conditions determining costs and demands. Various forms of traffic management (e.g. priority at lights or lane reservations) could affect running speeds and therefore costs; and indeed it may be argued forcibly that it is a necessary condition for effective action on demand either indirectly or directly that road space must be generated somehow initially, otherwise bus service adjustments are much restricted. One must hope that the initial intervention, as it were, would be justified ex post by success in attracting the required number of passengers. The effects of changes in physical conditions on the technical performance of bus services are very suitable for testing by field experiments. And it would clearly be sensible, if experiments in intervention by, for example, changing bus frequencies, are mooted, to attempt to provide for controlled, and variegated, associated changes in traffic management. There is here, a moral for so-called 'demonstration' projects designed to test the feasibility of improved bus services: the experimental situation must allow for comparative experience under different objective changes in physical circumstances i.e., several simultaneous experiments are required. They must be continued long enough for demand side effects to be realised - though one is still rather uncertain that demonstration projects, because they are usually known by intending customers to be temporary never can tell one much about demands.

Alternatively, or in addition, the government may seek indirectly to affect demand - e.g. by restrictions of various kinds on the use of private cars. These are likely to be crude instruments at best. The most favoured control - that of parking - suffers particularly from the drawback in the present context that it is relatively poor at generating road space in central areas (because of failing to control for through movement). We cannot delve into the intricacies of these indirect effects here however: but we should note that the calculations made in respect of direct effects of intervention must recognise, and allow for, the existence of external changes in the conditions.

Now, although we cannot trace out here the conditions for successful application of 'external' measures, inspection of the main alternative which we are concerned with, namely subsidy, raises a considerable question whether external measures affecting the running time for buses in particular may not often be far more effective and therefore more justifiable in a cost-benefit framework. These doubts arise from (admittedly crude) estimates of price and time elasticities such as those made by the Charles River Associates, in investigating one important case of subsidy - free public transport. There are a number of difficulties with the data and sampling which limit comparisons e.g. the estimates were made for zones including households, not for household choices directly: the public transit option includes bus rail and subway (the 'best' alternative from zones being selected, but the results are broadly in line with other studies of modal split and have the considerable advantage from one point of view, of distinguishing cross- from what are called 'direct' (what we have called 'total') elasticities fare and time elements; and different kinds of trips - work and shopping.

Generally, the results are as follows: taking into account the total travel measured (line haul and access from home to transit), the aggregate fare elasticity for transit works out at about -.17; that for shopping -.323. For time elasticities, the best estimate for both kinds of trip was 0.6, estimated at the means of the distributions(1). "Most of the cross elasticities" between auto and transit that were estimated were "very low, or zero", suggesting that "modal decisions are governed more by the socio-economic characteristics of the travel than by comparative times or costs of travel by the different modes", but, again, at a lower level, times were "more consequential than fares"(2). The authors' comment about "socio-economic characteristics" underlines the earlier arguments for calculation where these kinds of differences are controlled for. But supposing the orders of magnitude

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(1) pp. 97, 98, op. cit.

(2) pp. 46-49.

to be about right, three implications for our problem are important. For convenience we will speak of a form of intervention giving a prospective reduction in fares or times on public transport.

First, a given reduction in fares will have less effect for trips with a higher congestion effect (which we may identify with work trips usually made at peak times) than others (shopping trips, which include many made at off peak times). Second, the effect, such as it is, will be much more marked in terms of inducing extra trips from non-car owners (those without 'auto' options) than car-owners. Thus the prospective effect on congestion via car trip reduction is muted(1). Third, and perhaps most important, time elasticities were some three times, on average, fare elasticities(2). For substantial effect in increasing numbers of passengers, fare changes would have to be large enough to compensate for the time penalties typically suffered by buses in comparison with private cars. (This is the same kind of reasoning that underlay Moses and Williamson's opinion, quoted above, that negative fares would be required to shift substantial numbers from auto to transit). All this tends to limit the effectiveness of fare reduction, and thus subsidy, especially where congestion is an important element, as opposed to measures altering the relative times taken. Action differentially to favour bus speeds, as by differential treatment at junctions, may well be more effective.

Though, therefore, better investigations of demand could certainly indicate otherwise, a government might well be sceptical of the success of subsidy to public transport, in the form of direct subvention for fares, where decongestion is a major objective of policy. Such scepticism would also hold for subsidies to reduce public transport cost levels, e.g. a remission of taxes on fuel. A successful subsidy policy here requires discrimination between the services to be subsidised. This might well, on occasion, be effective as an 'external' subsidy. Thus, time elasticities are probably high for interchanges between public transport systems and between them and private modes; public subsidy to

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(1) The demand curve in the diagram covered all bus riders, of course. Decomposing the demand to car and non-car owners is necessary to compute and reveal effects on decongestion.

(2) Again both kinds were included implicitly in our diagram except that we recognised separately the time element arising from service frequencies.

stimulate improvement at these points would of course improve ridership, and may be necessary because of divisions of jurisdictions over investments. Essentially, however, something analogous to careful market discrimination is required for greatest effect - e.g. to attract the driver for whom competition in the household for the available cars is high, to attract custom at particular times of day and in particularly congested corridors of movement. The difficulty for public policy of course arises from that congestion reduction via subsidy for public transport must be focussed on those with options to public transport and that the beneficiaries from decongestion mainly private car users and commercial interests. This may in turn imply a conflict with other public desiderata - e.g. the view that subsidies must on balance benefit the poor. The importance of this as a drawback would presumably depend on how subsidies are raised, and this leads us to glance very briefly at this question.

Insofar as this presents a general governmental problem we shall not rehearse the obvious and well argued, if rarely concluded, debates on the merits of various taxes, local or central. But one point should be raised here, however: that one source of subsidy for a particular service might of course be the above-normal profits carried by the operator on another service or services. This is usually rejected on the score that production of the services in question would be restricted. One would expect this argument to be reinforced generally by the considerations discussed in this section, for low public transport output generally implies extra congestion. There is, however, one possible exception, namely that it is possible that any shift to gain extra revenue could lead an operator to reduce bus frequencies, and thus contribute to decongestion by the 'bus' effect. If existing passengers discouraged from trip-making by bus are non-car owners, they do not lead to worsened congestion, and so a net decongestion effect may ensue. One imagines such cases are infrequent enough to form a serious source of revenue for required subsidy. A much more important likely source in practice is (in the United Kingdom) non-urban operation of inter-city express services which still enjoy excess profits(1). The usual counter arguments about the allocation of resources to this apply, uncomplicated in essence by congestion problems. A compelling practical reason to avoid cross

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(1) Cp. Beesley and Politi: Economica op. cit.

subsidisation is probably however precisely that it is a very unconvincing way of redistributing income from the better to the worse off - nowadays most cross-subsidisation in public transport in urban areas, the subsidy by the poor (the captive riders) to the less poor. As we have indicated, public policy tends to exactly the opposite endeavour, one which we discuss in the next section.

IX. Subsidising the under-privileged via Public Transport

A considerable amount of work has been recently done in the United States on the question of justifying the provision of public transport, perhaps at zero fare, for certain specified classes of persons. The work is interesting in that it has thrown up a considerable amount of fresh information and has begun to consider options in public transport provision. It has concentrated on the poor and residentially handicapped (i.e. those forced to live by housing discrimination at a greater average distance from available jobs than others). Besides being important classes in themselves, they usefully stand for the kind of problems faced by any cities where the underprivileged own many fewer cars than the average of city dwellers. (As we shall see, the problems and possible solutions are much more dependent on pervasive features of urban form than specifically American features).

The first question, of course, before considering the evidence is why should a subsidy be paid via transport, when a direct subsidy to income could in principle be available, and would, by familiar arguments, generally be considered superior for a given outlay in terms of the receivers' welfare. Neither is transport normally considered a merit 'good'(1); nor, we have seen, can a government subvention easily be justified via scale economies and, from the arguments in section II, the case based on inefficiencies in transport as a whole must be weak too. The answer must be simply one of habit and expediency - habit because traditional cross-subsidies within transport have been aimed, at least, at underprivileged classes (though as we have just seen, probably

(1) i.e. a 'good' which (like education) the social judgement is that more should be consumed than individual consumers would freely buy.

increasingly failing to do so in fact). Expediency, because a given 'government's' powers - particularly at local level - may make it difficult to redistribute income directly or because the costs of subsidy can be made to fall on an acceptably uncomplaining group. Although little new or useful can be said here about these points, certain clear indications about the effectiveness of alternative forms of intervention do seem to emerge from the material(1). That is, we approach the question by assuming that on grounds of expediency a government is prepared to provide subsidies in this way, and is seeking guidance about how best to do this. It seeks to maximise the pay-off to a given level of subsidies.

It is useful first to review some of the findings. The most important source of disadvantage to the underprivileged arises because of the costs of work-trips. From a study of Boston, supplemented by data from other cities, Herr and Fleischer(2) find that the dispersion of distances between residence and employment is substantial among the poor and is likely to increase over time. So, if a transportation system is to serve the poor it must be capable of coupling many origins and destinations. Large scale improvements (typically these are suburban to centre rapid transit systems) promise little to improve their position. Specifically tailored bus systems to link low income areas with neighbourhoods with expanding job opportunities are, the authors argue, more likely to be effective. This is a theme also taken up by Ornati, who finds rerouting of existing bus networks to be the most feasible and quickly accomplished form of help(3). The Charles River Associates, discussing means to improve accessibility of jobs to ghetto workers find similar needs. They calculate, for example, that the cost for 42 new bus routes in Boston to link the ghetto areas with non-downtown job locations with quarter-hour bus services would be some $4.3 m. a year, or 6 per cent of the cost of a free transit service in Boston, and they clearly invite the conclusion that this kind of

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(1) An excellent summary is to be found in J.F. Kain and J.R. Meyer. Transportation and Poverty. Public Interest, 1970, pp. 75-87.

(2) The Mobility of the Poor, Joint Centre for Urban Studies, MIT/Harvard, Nov. 1969, Mimeographed.

(3) Transportation Needs of the Poor. Braeger, 1969, p. 89.

specialised assistance is much more to be preferred in cost effective terms. Improved travel within the city centre would benefit the poor differentially.

From these studies, however, the obvious form in which to decrease job-home distance is by encouragement of car ownership or the supply of near-car-substitutes (e.g. taxis). Thus, the poor (and ghetto residents) do not hold many fewer driver licences per head than do higher income groups. In Boston, of households in 1963 with less than $4,000 annually, the poorest group, only 35 per cent own cars but 54 per cent of all men and women have driver's licences. This latter figure compares with just over 2/3 for higher income groups. So increased ownership would presumably lead to a substantial lessening of the poors' disadvantages. A striking computation of job accessibility from two areas in Boston, South End, near the downtown sections and the other in a more distant suburb (West Newton) illustrates the gain in potential accessibility to relevant types of jobs by a shift to car. From the authors' material we may compute the following:

Table 3

Increase in Available Job Opportunities by Auto compared with Transit

Moderate Income Jobs Reachable within:	South End		West Newton	
	No. of Jobs available via Transit	Increase via Auto	No. of Jobs available via Transit	Increase via Auto
10 min.	5,500	47,500	1,400	5,200
20 "	82,500	54,400	3,800	43,600
30 "	118,600	94,700	9,800	133,200
40 "	159,500	113,700	38,400	229,200
50 "	187,900	156,900	112,800	230,900
60 "	234,000	127,200	152,500	219,200
70 "	254,800	124,500	182,100	203,600

Source: Herr and Fleischer, op. cit., p. 27.

Not only is the increase if an auto is available very substantial in both cases, it is extremely large in the suburban case, thus underlining the potential advantage of providing cars or near substitutes, especially as households disperse(1). Interestingly, the poor (in Boston) already seem to attempt to use a near-car-mode widely. Comparing modes used by <u>non</u> auto owners, the lowest income group made proportionately more of these total trips as auto passengers, and, surprisingly used taxis relatively <u>more</u> than did income groups on the average(1). This was no doubt somewhat influenced by the supply side, as taxis are probably more easily hailed in dense, predominantly low-income housing areas but, in view of the very high relative cost of taxis, this evidence might well be related to an adjustment for the disadvantages of job locations. More detailed analysis of work trip modal choice by location of residence would be needed to establish this definitely.

Thus the thrust of these studies is that subsidy, if it is to be given, should be directed to encourage auto use, and to explore, in consequence, the obstacles to "owning a decent auto" (to quote Herr and Fleischer)(2). These obstacles are, for example, the high 'threshold' costs of insurance and the cost of parking near at home. But clearly direct subsidising of ownership through offsetting these costs is very close to giving a subsidy to incomes, if it is to be aimed at specific groups. (These would have to be checks to reimburse expenditures, for example).

These are cumbersome forms of subsidy. If, indeed, it is impracticable to augment incomes directly, a less cumbersome form than these, and nearest to a non-income subsidy, is a form of

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(1) This kind of calculation - specifically and carefully comparing relative accessibility by mode is made much more rarely than it should be. It could throw great light on the advantages of a switch to cars by location and thus car ownership. Thus, for these observations, suburban dwellers are under far greater inducement to buy cars to gain greater accessibility than are in-town ones. More important perhaps, this is true for residents at the 50 minute job level where the potentail gain is at its maximum - and that quite markedly. One can also begin to estimate systematically potential gains and losses for increasing or decreasing trip length in terms of changes of accessibility by using these kinds of data.

(2) Proposals for this are found, for example, in S. Myers 'Personal Transportation for the Poor'. Conference on Transportation and Poverty. American Academy of Arts and Sciences, 1970.

travel voucher, to be expended by the recipient as he or she sees fit on the most advantageous mode. In combination with this, however, it would be sensible to lift conventional constraints on car substitutes. One, in particular, would be to end the rationing of taxi licences where these show positive monopoly rents - as they do in many cities. Another would be to repeal restrictions on the use of private vehicles for hire subject perhaps to enhanced safety regulations (so that payment for 'lifts' may systematically be made)(1).

A fortiori, moves such as this are calculated to help even more directly non-car driving groups. These overlap considerably with the traditional recipients of public transport cross-subsidies namely - the young and the aged. The latter especially require, for effective assistance from transport, door-to-door services, and the closer they are to the private car's standard the better. The arguments in this section which have been concerned essentially with the problem of securing a good result for subsidies in cost-effective terms may well strongly be influenced by two other considerations. In respect of the young, transport is complementary to education; and since education is itself nearly universally held to be a 'merit' good, transport subsidies for this group acquire a parallel approval. Less obviously, in respect of the old, the social problem is to support the personal desire for self-help and independence which is such an important element in their well-being, in a manner consistent with a high potential for access to persons and institutions and the kind of near-car services we have discussed are useful here.

X. Other specific arguments for subsidies

We may more briefly deal with arguments (b), (c), (d) and (e) of section VI. The efficiency arguments for subsidy from the relative position of the supply and demand curve for a service in the urban context is a special case of the arguments deployed in discussing the cost-benefit analysis of subsidies. The essential problem is to justify the exceptional treatment of an 'industry' which would not otherwise exist. If such a justification is to be found, it will be along the lines indicated in section IX. An alternative to subsidy in this case may be price differentiation,

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(1) Similar points are made by Kain and Meyer, op. cit., p. 85.

which may generate sufficient revenue to cover costs. The argument for this in turn rests on the arguments from the distribution of income which were also reviewed above. The arguments there about the provision of relevant services may lead to the device of subsidy in a case where service does not exist, and could not exist, without it; indeed, as we have seen, specific new services are very likely to be needed for an effective meeting of the identified potential demands.

The case of subsidy in the spirit of an 'infant industry' turns in part on considerations such as those just referred to e.g. it may be that the income effects of a tailor-make service to the out-of-work will eventually sustain a service without subsidy - 'eventually' because adjustments take a long time, and by definition, such a service may be regarded as high risk by established operators, thus calling for a temporary subsidy to demonstrate viability. The argument is often used to support subsidy for large scale (e.g. rapid transit) investment, however. In so far as scale economies are concerned, we have already voiced strong doubts about their importance. If they do exist and are predicted correctly, then no subsidy is called for; the capital will be supplied by the market. A subsidy to overcome what are thought to be incorrect predictions (i.e. in a case where the market is thought to be unwilling to supply the capital) involves a judgement that superior information is generated somehow by a government. This may be the case, but it is perhaps unlikely. In fact, however, there is a further connotation of this line argument, as follows.

Normally, one would argue that if scale economies - e.g. on commuter rail lines - exist, then an optimal marginal cost-pricing policy may involve, as one possibility, subsidy to users via the operator. Commuters invest in residences; and other investments are made on the assumption that subsidised prices will continue beyond the life of the rail line assets. Eventually, therefore, it is argued, when rail assets are renewed, there may be a rise in the actual prices to those who have been 'misled' into investments. This is held to be an argument against subsidies(1). But it is a piece of special pleading of course in that it assumes a lack of foresight or reasonable expectations

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(1) Cp. Meyer Kain and Wohl, op. cit., pp. 343/4.

combined with a change of pricing and subsidy principles by the government. However, on equity grounds it cannot be dismissed, and for that matter, neither can its obverse, that a failure to subsidise is inequitable. Here again, it behoves a would be subsidiser to look very carefully over the actual services to be provided to specific groups.

The arguments concerning the provision of 'optional' transport facilities are in part more familiar in the guise of arguments for a 'stand-by' payment to railways(1) to cover reserve capacity against potential use. Now, commercial operation will itself provide for some excess capacity, of course, that is infrequently used by passengers, for it will pay the railway to provide this. Only if a non-commercial pricing policy is insisted upon, or specific charges to reflect unusual use are impossible or too highly costly to organise and collect, will there (allocative) case for subsidy. In the first case the reasons for not adopting a commercial policy must be scrutinised and the basis in equity revealed. But it may well be that railways, in particular, can provide e.g. 'bad weather' alternatives which, when used, are difficult to price in practice. And it may appear particularly inequitable that 'regular' users should be 'penalised' without redress - which could be equally costly to manage - when service qualities deteriorate as the extra 'bad weather' passengers joint the trains. The subsidy may thus be justified solely on efficiency grounds where costs of setting prices exceed the net benefits of provision; but one imagines that the sums computed would be insignificant(2).

There is another sense in which the provision of an 'optional' service is argued for, however - that in general the presence of capacity, is useful, even if never used. That is, it is comforting to know of alternatives, even though one may never use them. This kind of argument has a curious status. Clearly, there is some value to me in having such an option, and I might be prepared to pay something for it, and so would others. If there is no practical means to convert our wishes into cash, then one might

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(1) Cp. S. Joy. The Standby Concept on Railways. Jl. Tpt. Econ. Policy, Sept. '67, p. 143.

(2) The issue was pursued in the B.R. and Ministry Joint Steering Group Enquiry and abandoned for lack of substance.

justify a subsidy on similar grounds to those just discussed. But the category is bound to be somewhat illusive - in that, of course, just such an argument could be raised about any good or service that I do not but might want - though which I have no plans to consume. If 'options' are to enter all allocation transactions, as would be required for allocative efficiency were such arguments to be followed, one suspects that little practical prescription for change would result and so for this reason too we may accord the case little weight.

A final word may be added on the 'aesthetic' arguments for subsidising particular forms of transport. These have, by definition, no cash alternative - that is, no practical way of 'internalising' social costs and benefits. They may be legitimately treated as part of the cost benefit analysis described earlier and thus correctly find their reflection in subsidy. There may indeed be strong arguments for use of subsidy as opposed e.g. to road pricing in this area - for example. I have shown elsewhere that the correlation between the beneficial allocative effects of road pricing in urban areas and of road pricing's effects on noise and safety disbenefits in particular may be perverse(1). However, to be effective, subsidy must deflect behaviour towards a mode less objectionable from these points of view, and the beneficial effect is limited by the income effect of reduced overall payments by customers for transport, stimulating use of the 'more objectionable' mode - for example, roads. In practice, though this may mean that undergrounds are in particular favoured, but no-one has yet claimed a substantial aesthetic effect in increasing this mode's usage. Far more effective in terms of actual diminution of nuisance would be specific physical constraints on traffic movement (e.g. in certain residential areas as given times, etc.)(2).

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(1) E.C.M.T., 1968, op. cit.

(2) If a subsidy <u>is</u> to be operated for the purpose of protecting aesthetic values, it might well be best, in a cost-effective sense, to arrange for an overall budget to be allocated (by, say, a council appointed for the purpose) to 'purchase' reductions in 'offensive' uses by augmenting, say, an urban road budget. John Kain and I discussed such a device some years ago in "Traffic In Towns" Urban Studies, Nov. 1964. The 'council' would select particular roads where traffic is to be discouraged and compensate the road users by augmenting the total funds available to them to increase capacity elsewhere.

In sum, we find that these 'lesser' arguments, taken singly, are incomplete, trivial, or would better yield to alternative treatment. One must always beware of a process of division and rejection however. It may be that occasions can arise where there is a conjunction of favourable arguments; these however will concern specific pieces of intervention or investment. The moral is that a selective and mixed strategy - including some subsidy is likely to be the 'best' for a given government to pursue.

XI. Form and Control of Operator Subsidies

(a) The significance of the industry structure

Assuming a 'government' has decided, perhaps by what might be a rather crude cost-benefit analysis which has included major alternatives to subsidy to operators if available, that certain services are probably worthy of support by subsidy, the question of the best form for them to take arises. Ideally, the form and control would be part of the cost-benefit appraisal itself: there should be simultaneous consideration of the advantages and disadvantages of possible forms and controls. But in practice - especially, where, as often will occur, a general poorly rationalised subsidy is proposed to be transformed to a more purposeful set of specific subsidies, questions of actual operation tend to be left to be hammered out after the main decision has been taken. In any event, the system adopted must be such as to generate more information relevant to the government's future choices. A feed-back to the cost benefit analysis is essential so that a continual improvement in rationalisation and therefore greater net benefit is in prospect. As we shall see, objectives of maximum economy in the operation of subsidies - a common pre-occupation once the principle of subsidies has been accepted - do not necessarily coincide with the information requirements. ('Economy' may be concerned either with resource costs or with the government's outlays or subsidies). In what follows we shall also assume that the "government's" cost benefit analysis has dealt with the problem of accountability for subsidies to a wider public or superior government. So the problems of a government department subordinate position influencing the form of contract with an operator do not arise - a case met with, for example, in the analogous problem of setting defence contracts, as argued by O.E. Williamson(1).

The first, and much neglected question, is which party initiates the proposal(s) for subsidy? Clearly, this will much depend on the structure of the operators' industry. The polar extremes, useful for analysis, are competition and monopoly. Where the prospective suppliers of a service are in competition, as may be the case with bus operation, then the initiative must chiefly, one supposes, lie with the government, who will thus be responsible to the generating and evaluating proposals (in a cost benefit framework). It will rely on competitive bidding to provide the service, and, just as important, it can seek tenders for services of different kinds to form ideas about prospective costs of services but it will not expect initiatives from the industry.

On the other hand, with a monopolistic operator structure, the most likely case, initiatives could arise from either side of what is essentially a bilateral monopoly relationship. Since the major repository of operations knowledge is the operator, a government would sensibly attempt to encourage initiatives from that side. Hence, in general, in a bilateral monopoly situation, the government might well seek to ensure that in the long run the conditions under which subsidies are given are such as to engender the impulse towards initiation. This is very close to the problem, already mooted, of encouraging innovation, and we shall come back to the question of the industry structure later.

(b) Subsidy operation with a competitive industry

In terms of securing economy of subsidy, and assuming first the operators to be organised competitively, it may seem that all a government has to do is to fix the required quantity of services required (passenger trips) and the standard of service (e.g. number of buses per hour on the route) and request bids, taking the bid requiring the least subsidy. (It might perhaps also insert a constraint on bidders as one way to secure some desired level of certainty in the expected quality, e.g. by requiring a deposit

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(1) In 'The Economies of Defense Contracting: Incentives and Performance': O.E. Williamson, Issues on Defence Economies. R.N. McKean, Editor, Columbia University Press, 1967.

from bidders, or confining bids to lists of 'established' operators, etc.). These latter constraints are of course a minor barrier to entry which will increase somewhat the government's outlays. But the question of the length of the contract is important. There is necessarily an element of uncertainty about the length of time the service(s) will be supported - i.e. the cost benefit analysis parameters and therefore the conclusions may well change over time. This will hardly trouble a government which faces basically competitive operators, except that it may well pay for it to ask for tenders for alternative lengths of time - say 1 to 3 years. This may be advantageous for two reasons - first to take advantage of what (mild) forms of product differentiation in the bus industry there may be (e.g. it is likely that a three year period would be more productive of bids based on higher quality coaches than would a one-year bid) and because it may wish to incorporate differing costs per period, as revealed by bids, into its own estimates of the net benefit yields likely over differing periods(1).

When a contract is awarded, and the period fixed, the government will still wish to learn from the experiences of the operator. This requires further attention to the form of the contract, and attention to interpreting the experiences of the operator. The government wishes to know whether, in the event, more or less passengers than predicted were carried, and similarly the performance of costs against expectation. The most likely object of concern, of course, is the demand side, because this is the main link to the most important elements of the cost benefit calculation.

So the government should provide for reporting of actual passengers carried, and be prepared to incorporate this into the tender conditions. But although the number of passengers and thus the target fares to be achieved will be predicted by the government as part of the cost benefit exercise, there will typically be uncertainty about how many will actually be carried. The government may well regard more favourably an outcome higher than predicted than it would regard one that turned out to be lower; first, for the reason that the corresponding cost benefit outcomes

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(1) The government's time preferences may well also differ from that of bidders, giving it a further reason to seek bids based on alternative periods.

may be more favourably disposed to an 'error' in that direction, and second because it wishes to learn more about the circumstances in which bus patronage may be increased. In this case, it could decide that the best form of contract to be put out to tender is one with two elements - one corresponding to a basic service, say of x vehicles an hour representing the best estimate of the outcomes, and a second to correspond to the passengers carried. Bidders will have their own estimates of the likely demands at the given fares, and will, presumably, propose varying bids for the different elements, and the government will choose according to its own estimates of the worth of attracting more passengers. Essentially, then, information can be 'bought' by adopting, and paying the costs of, an appropriate form of subsidy. Careful attention to the varying circumstances of services proposed for subsidy, combined with a mixture of incentive bids, could further increase the government's ability to learn about demands from the subsidy experience.

If the government is concerned to experiment in entirely new kinds of services for which there is rather little in the (competitive) operators' past-experience to base accurate bids upon, it might well consider nomination of individual operators and remunerate them by some form of cost-plus profit contract. (So, in effect it 'bribes' an operator to be an innovator. This, in contrast to the situation of bilateral monopoly, does not lay up possible difficulties of feed-back to negotiations for other services). Thus with competitive bidding, the <u>form</u> can be chosen to allow for information-gathering. <u>Control</u>, i.e. monitoring, is a relatively minor problem of ensuring reportage of passengers.

(c) <u>Subsidy operation with a monopolistic industry</u>

The problem is very different, however, if the industry structure is one of monopoly. Such a position exists with the United Kingdom's major practical example of urban subsidies - the British Rails' "grant-aided" (subsidised) passenger services, where the Government, since the 1968 Act, has granted aid for 1, 2 or 3 year periods to specific services, in response to cost-benefit calculations. The monopoly power of the railways is very limited, of course. For example, the government considers alternative bus services, but this is a more active option in non-urban areas than in urban(1). It is also very reluctant to allow urban rail services to be withdrawn (though the present government is revising the late government's attitude to London commuter lines whose subsidy is to be withdrawn next year). The experience so far is instructive, in that it illustrates well the difficulties inherent in what is, within strict limits, a bilateral monopoly situation. In the analysis that follows we shall draw on some of the experience of defence contracting, where most work pertinent to our problem has been done.

In a situation of bilateral monopoly, a contract for services may take two basic forms (again they are assumed to be fixed by cost-benefit analysis from the government as to target quantity and realised price). First, the ex-post subsidy, where costs are ascertained after a given period and an agreed sum including profit paid, and second, the 'ex-ante' type of contract - called, for example, a 'fixed price contract' in England(2). Most governments have tried to work towards the latter type. The basic argument is of course that the ex-post payment type reduces the incentive to perform efficiently - i.e. to save resource costs. Given that a government must consider accountability to the public at large, this is in practice bound to be a compelling basic stand. This is reinforced in the British Governments case by its determination, embodied in the 1968 Transport Act, to promote net-revenue maximising behaviour by British Railways in its non-subsidised activities. (A whole series of changes in the structure and financing of B.R. was instituted to attempt this). It would have been inconsistent, and confusing to management effort, to have selected an ex-post form of subsidy.

However, the ex-post payment does, from our analysis above, have something to be said for it. Ex-ante contracts keep the operator at arms length, but at a sacrifice. If an ex-post system is adopted, this effectively focuses attention on the non-efficiency aspects of the relationship, and may well lead to a freer experimental situation where much more information about

(1) E.g. the Cambrian Coast cost benefit study of a line closure in rural Wales illustrated the vast superiority of the bus alternative for most passengers.

(2) Second Report of the Enquiry into the Pricing of Ministry of Aviation Contracts, Cmnd. 2581, p. 6 ff. There are variations, to be discussed below.

cost and demand conditions can be established. And in the field of defence contracting, where the government may well have an interest in the long run improvement of contractors technical capability, Williamson makes the point that with cost-reimbursement types of contract, there will be a tendency to expend 'investment' type expenses and thereby improve technical capabilities(1). Inflation of the cost base may thus have long run benefits. But there may well be ways of trying to secure this effect without having to run a general risk of generating slackness in pursuing efficiency. For example, specific research and development subsidies may be adequate for the conditions of urban transport. On balance, the ex-ante contract seems more likely to be the appropriate basic form.

The two major variants of the 'ex-ante' contract are traditionally the 'cost plus fixed fee' contract, and the 'incentive fee contract' - or the 'target cost' contract as it is known in British defence literature, to which we must turn for relevant discussions of the problems. Both types in fact require the establishing of a target cost; in the first case the profit is fixed, and thus an incentive to economise on cost remains; in the second case variations in realised costs are shared between the parties - so that realised profits are increased if costs are under target, and are reduced if over target. Assuming that required quantities of (passenger) output are given, two kinds of problem arise: the fixing of the target costs on which subsidy levels are worked out, and the question of which kind of contract will in fact lead to lower resource cost.

The fixing of target costs raises difficulties when applied to railways (though it does not, as in the case of defence contracting, have to contend with considerable prospective innovation in technique). Railway costs tend to fall into two categories - the estimatable (given reasonable effort) and the non-estimatable (because joint). Thus what uncertainty there is about railway costing essentially concerns track and signalling, and even that may, in some circumstances, become attributable to specific services, as we shall see. Where true jointness of costs

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(1) P. 225, op. cit. Also, if ex post profits allowed are low, there is an incentive to switch resources elsewhere. This may be useful if the essential problem is to allow for a less than expected number of passengers - ex Cmnd. 2581, p. 7.

exists, no allocation to services is in principle possible, hence no resolution of 'cost' is possible. High cost uncertainty, which gives both parties to the contract an interest in suitably adaptive behaviour during the contract period is not present in the railways. Thus a major reason for adopting the second kind of contract - the incentive fee - does not apply to railways.

In a real sense also, then, neither form of contract can in fact apply to railways unless - as is unusual - a whole line is coextensive with the proposed service for subsidy, because a target cost is impossible to fix in advance which will necessarily be reflected in resource use. Passenger services which are commercially viable run alongside subsidised ones, and 'profitable' freight services may also share common facilities. Nevertheless, a subsidy must, it is felt, be fixed in advance. If it is, and given that there is agreement in advance on attributable costs on some formula, there is a positive chance of a realised surplus to the undertaking arising out of the contract. This point came out strongly in the United Kingdom Committee of Public Accounts' first examination of the British Railways' grant aided services (1).

Grants for the 'socially necessary' services were fixed by one of two methods: the first involved an arbitrary division of track and signalling costs by reference to ton mileage and train mileage run respectively by passenger and freight services. In this case, a fixed amount was paid in respect of a (subsidised) service; the actual surplus realised depended not only on performance in respect of allocable costs to that service - a reasonably predictable item - but to the decision about the routing and realised profit margins of other train services.

This gave the railways an incentive to switch operations to grant-aided routes. Where excess capacity existed, this made the correct incentive to efficiency, but the amount of subsidy was not minimised. This could only have been realised either by the Governments attempting to decide, ex-ante, the correct (commercial) policies and pricing for commercial services, or by ex-post payment according to realised surpluses over allocable costs on the commercial services. The first was quite contrary to the

(1) March 1970. Committee of Public Accounts: Civil Appropriation Accounts Classes I-IV 1968-9 p. 327.

general policy of encouraging a commercial attitude in British Railways, and the second of course would have sharply reduced incentives to efficiency (though it might have lessened the government's cash outlays for subsidy).

The second method applied where it was clear, ex-ante, that the entire track and signalling facilities would be needed by a passenger service submitted for grant aid (i.e. the service could not be operated if these facilities were reduced). In that case, all such costs would be attributed to the passenger service, leaving the railways to operate freight over the lines concerned with 'free' track and signalling. Thus they could profit by any freight carried at prices above freight's attributable costs. Again, the inducement to use facilities intensively is applied, but the subsidy was not the minimal necessary to induce the provision of the subsidised service.

Of the 240 passenger services grant-aided in 1969, 90 were aided under 'Method 2'(1). The selection of either method depended greatly on a judgement about the significance of freight operations. Method 2 was adopted as an option chiefly to avoid the difficulty, inherent in method 1, that where passenger services dominated the provision of track and signalling, the cost of withdrawal of passenger services might be underestimated. In these cases, abandonment of passenger operations might leave a highly unprofitable operation for freight. Freight services would have to be abandoned if the line as a whole were closed. So Method 2 was calculated, on the one hand, to encourage the carrying of freight where margins over allocable costs were low but positive, but on the other, clearly to demonstrate to both B.R. and the Ministry of Transport on behalf of the Government what the cost consequences of abandoning the subsidised service would be. The method was applied particularly to very lightly trafficked rural routes and to London commuter lines.

(d) Problems of control of subsidies: the United Kingdom railway case

From this experience it seems clear that while the direct incentives to economy were provided by the system, considerable

(1) Op.cit. p. 3361. Interestingly, Method 2 would be inconsistent with EEC rules; method 1, consistent.

problems still remained. Because the realised subsidy might be more than intended, cash to support other railway activity, including investment, would be generated. How far this would be acceptable, of course, depended on the view taken of the success of the general policies designed to increase the railways' commercial orientation. In respect of the grant aided services themselves, the Ministry needed to generate more information to increase its capability of judging the support versus withdrawal issue. It was continually under pressure to demonstrate subsidy-minimising efforts from the parliamentary system of scrutiny of public accounts - a system not well versed in the intricacies of railway pricing and costing. Naturally it took steps to increase its ability to predict the effects, and to narrow the scope for unintended consequences, of its actions.

One such possibility was to try to set independent limits, ex-ante, on the amounts granted. According to one well-informed writer speaking of the likely development of the system in early 1969, the Ministry "intends to vary the B.R. costing rules .... when the system of grant-aided operation has had time to settle down. While the Ministry, at one end of the scale, will never pay less than the minimum cost of providing the single track necessary to run a one engine in steam shuttle service, at the other it will require that the amount of the allocation of a joint cost to a grant-aided service shall never be more than the cost of providing a similar facility, if the grant-aided service were operated in isolation. For example, on a route carrying (other 'commercial' traffic) total track and, signalling costs are likely to cover many facilities needed solely to operate the commercial traffic .... the expense of a signal box whose sole function is to control entry into an industrial siding, for example, will eventually be eliminated from the cost base."(1) Thus, it was asserted, an attempt would be made to put upper and lower constraints into grants - apparently, according to the same source, against the wishes of B.R.B., who regarded the attempt as "too hypothetical". But since it was also admitted that the application of the constraints might well not lead to lower grants in total, the procedure probably would have had little practical effect even if practised. Thus uncertainty about the degree to which the grant-aid system has unintended consequences of supporting railway finances persisted.

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(1) Op. cit., question 3186.

Since the accuracy of ex-ante control could only be increased with experience, grants were limited in time, steps were taken to increase information flowing to the Ministry, and methods of coping with initial errors instituted. As the Permanent Secretary of the (then) M.O.T. put it in 1970, when defending the grant payment methods in a Parliamentary enquiry, 'I can see no real way in which we can write in an incentive to the Railways. What we have to do is to try and be a capable watchdog.'(1) (He meant that there was no way in which the Ministry could ensure minimum possible subsidies, for reasons such as we have just examined).

The major steps taken to increase the 'watchdog' capability seem to be as follows. Grants were given (from 1969) for 1, 2, or 3 years, presumably following the Ministry's own estimate of the likely packing order when its own techniques of appraisal were more firmly established. According to the evidence at the enquiry, it found that it had to cause costing and revenue exercises to be made for services which hitherto had been merged in groups, even though the railways had hitherto held that no separation of data was possible. This was especially true of major conurbation services. In London, a grant for the Southern region, including 99 services, amounting to £10 million, was to be split up, in future negotiations, first to 8 sectors, and then to 17. The Ministry's preferred position was to "treat the Southern Region as 99 services"(2). The translation of existing services elsewhere into meaningful entities for subsidy purposes has also on occasion been difficult. The basis for recognition of a service (e.g. when is a stopping service on a given route to be distinguished from a non-stopping) is, in principle, it appears, the persons involved - do they represent a different market?(3)

Several grounds for renegotiating the original contract were recognised. Thus, the fare levels were predicted in the original negotiations, but the Ministry might - under pressure perhaps from macro-economic considerations - disallow fare rises intended to cover cost increases, which then ranked as a reason for variation in the contract. Obvious computing errors, admitted on either side, also ranked for correction. Again, if major

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(1) Op. cit., question 3186.

(2) Qu. 3192, op. cit., Qu. 3246.

(3) Qu. 3233.

assumptions about demand for a service are shown to be mistaken, this might also justify a modification, at the Ministry's initiative. In order, among other things, to trigger this action, twice yearly counts of passengers on each subsidised service have been initiated.

Other features of the 'watchdog' process included: audits of a number of the grant estimates as submitted by the Railways were made "to see whether fair use has been made of all the available figures and the detailed rules (the M.O.T.) has agreed with the (Railways) Board as to how costs are to be allocated have been followed". The witness went on to say that "The Board of course have to report in their annual report, not grant by grant but globally, what have been the actual results compared with the estimated results. So we shall over a period get an idea of how good they are at this."(1)

(In this latter check the M.O.T. was apparently disappointed, for a writer in Modern Railways later remarked of the annual report in question that "the report's implication that the B.R.B. does not yet have a detailed idea of the grant-aided network's performance in isolation must dissatisfy and depress many of its friends"). A check by comparison of estimates is made to detect local exceptional variations in cost, to become the subject of enquiry.

In these ways, then, the Ministry sought to build its capability for control. Some obvious gaps remained. The cost information was based on "spatial, not temporal" information - i.e. no attempt has yet been made to attack peak problems directly, though the more detailed specification of services must go some way towards this(2). "Contributory revenue" - i.e. the revenue accruing to a subsidised service by virtue of associated travel on possibly profitable parts of the network is not considered in the grant negotiations(3). This appears to be partly a result of the traditional identification of the contributory revenue question with

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(1) Qu. 3249.

(2) "We think in terms of physical capacity rather than what I might call temporal capacity." - Q. 3385.

(3) Contributory revenue <u>is</u> taken into account in assessing the 'future of the line' - presumably, therefore, in cases where complete withdrawal of services is contemplated. - <u>Q. 3242</u>. This would be consistent with the closure cost and revenue formular now adopted in the United Kingdom.

branch and therefore basically rural lines. In conurbations it may assume considerable importance - particularly where the calculations are intended to be tied to cost benefit appraisals. If, for example, as we saw earlier, the withdrawal of suburban bus routes is alleged to have measurable effects on longer trips by rail, then the presence of railways own radially oriented conurbation services will certainly do so.

(e) The lessons from the United Kingdom railway experience

The main lessons from this experience - still a comparatively new one - seem to be as follows: the system of control can at best narrow the unintended consequences of specific grant-aided systems. That the control can be improved, in the sense of reducing the railways windfalls is suggested by the fact that of 69 services receiving a 2 year grant in 1969 and for which comparable data are available 25 have, in a period of rising prices been reduced, and 39 increased, by amounts of up to 60 per cent(1). This presumably largely reflects more accurate data. The direct cost of the system is high to the parties: the Ministry estimated its costs for administering the grant services at £73,000 for 1969 (Q. 3298) and the railways costs are estimated at 'over £500,000' a year(2). More important, they absorb a large amount of management skills, of high opportunity cost on both sides, particularly on the Railways side they divert negotiating skills useful for driving better commercial bargains. On the other hand, the information needs of commercial market decisions and subsidy decisions have a large area of overlap. The pressure to specify the profitability of services has a beneficial by-product in forcing the attention of management to such issues as the origin and destination of passengers; it is made to be much clearer about in what a passenger market consists. There has been, one would judge, a net stimulus so far to more accurate and generally applied information. The direct stimulus to economic efficiency given to the railways, has been noted, and has had the effect, at least in part, to search for consequential commercial advantage - e.g. plans to double off-peak frequencies in the London West region

(1) Source - Modern Railways, March 1969, and The Times, 15th January, 1971.

(2) G.F. Allen, Modern Railways, January 1969.

services has been associated, by one commentator, with the grants(1). But, if the policy of specific grants is continued, the Ministry will become more and more closely involved with the scrutiny of railways affairs. This might raise essentially the question of a growing identity of interests between 'controllers' and 'controlled' which has exercised commentation in the defence contracting field.

The last point brings up again a very basic question - can a policy of subsidising specific services, whilst maintaining commercial operations in general, be sustained where the supplier is monopolistic? The model which we economists have had in mind for this, our favourite prescription for dealing with socially necessary services, has imagined a government in position to use the free market as a reference point; action by operators is highly constrained by actual or potential alternative suppliers. But, however ingeniously contracts are devised, one suspects that in a case like that of the railways, discussed here, over time the railways must either become, as it were, managing agents for a government, with major decisions taken for them, or that some accommodation short of the ideal selection and maintenance of services will be reached. The first is sure to be resisted strongly by both parties. The second seems far more likely. In particular, pressure towards minimisation of subsidy outlays by the government might result in some de facto re-establishment of cross-subsidisation. One can imagine that at some point the implicit bargain will be struck such that a cost justification for a service here will not be pressed too hard so long as the claims for a larger subsidy for a service there are likewise not pressed but the service is kept in operation. The railways' interest in this may be logical for them if, as is traditional, they are reluctant to see a contraction of the rail network. There are of course speculative points; experience may prove them to be of relatively little importance.

More important is the question of developing the capability for social cost-benefit analyses on the government's side - in the case under examination, the Ministry's. Whatever model of subsidiser-subsidised relationships is applicable, clearly the subsidiser has to develop this capability. Does it need a

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(1) Modern Railways, September 1970, op. cit., p. 366.

capability to initiate services for subsidy? From the experience reviewed here, it may be argued that it does. True, in this particular case, the 'stock' of services to be reviewed was very large when the subsidies were first granted - over 2/3 of all passenger services, we may assume, were considered for submission for grant by the railways. But as the 'watchdog' activities are increased, the possibility of missing potentially worthwhile proposals from the viewpoint of net social benefit increases if initiation is, as now, wholly on that side.

In this connection, a relevant feature of British Rail grants is that they are intended to cover all costs, including renewals of assets at replacement (not historic) costs. If a grant-aided service is discontinued within the duration of the grant, the Ministry is liable to refund any authorised expenditure on assets bought specifically for the service and shown to be useless in other services; and, on the other hand, if B.R. has actually spent less than the depreciation allowances written into the original contract, it is liable to refund to the Ministry(1). This practice ensures that the railways maintain an interest in submitting proposals. Nevertheless, the inducement to select 'social' services is in response to railway needs and not in response to their social desirability as seen by the Ministry.

In its appraisal of proposals in cost benefit terms, a government needs also to be able to economise on inputs to the evaluation process. Unfortunately, little light is thrown on this by the published accounts of the railway experiences, and indeed it may be an indication of how far away practical procedures are from the desirable form of appraisal that the Public Accounts Committee did not enquire at all into the workings of the social cost-benefit analyses. That there are considerable problems of generalisation from selected case studies a need to test proxy variables for items of costs and benefits and, in particular, a number of problems connected with the estimation of decongestion benefits that we mentioned in Section VIII, is in little doubt. In principle, too, proposals for subsidy as a whole should be viewed in the framework of the total public transport and road network, both to account for possible interactions between proposals (to avoid under- or double- counting) and to form some

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(1) Freeman Allen, p. 565, op. cit.

general notion of how much in aggregate might be gained from a given set of proposals. This raises questions beyond the scope of this paper to discuss in the detail they deserve. The large-scale urban transportation study does not, at present, yield such a framework, and conventional developments to extend them to incorporate more detail of public transport networks are extremely costly and, as of yet, of unproven utility. Exactly the same problems are encountered, of course, with the justification of large scale investments in urban transport.

The importance of gaining an overall view is broadly illustrated by the contrasts in assumptions about the gains from decongestion that we noted in studies quoted earlier: for example, in the Heathrow links study, only ½ the congested benefits potentially available from transfers from cars to public transport were assumed to be realisable, because of the generation of traffic to be expected on roads as a result of releasing capacity. No such assumption was made in the suburban bus study which we also quoted, which thus implicitly assumed that a very effective rationing scheme for roads would be in operation. Consistency of assumptions about what the general impact of total policy instruments on road demands is at least required, even if they have to cover a wide range. But to go further needs much more study. And if, as seems likely, the thorough integration of investment and subsidy proposals in an urban-wide cost benefit model is still some way away, careful monitoring of results against predictions for individual proposals, and the steady accumulation of more plausible behavioural inputs to ad hoc studies will have to be the main way to progress.

Consistency and a watchful eye for the overall impact of policy also require at the very least administrative co-ordination over the relevant urban area, and the absence of disfunctional financial constraints. The 1968 Transport Act marked what might be called a hesitant step forward in the United Kingdom in this respect. In that Act a 75 per cent 'infrastructure' grant from central government funds, for public transport purposes, was inaugurated. The reasons for this grant scheme were several. Generally, it was hoped to prop up ailing public transport, partly to 'equalise' the conditions vis-à-vis road expenditure grants, themselves already fixed at 75 per cent, and partly to create incentives for further local planning of transport needs. Thus, to get the government support a local authority would have to show a planning capability to receive the grants which were themselves aimed explicitly to induce attention to the planning of total transport systems, and in particular, the interfaces between existing modes. That attempt to promote comprehensive planning was no doubt a move in the right direction, for it attacked directly the question of improving the conditions of the initiation of projects.

But the move was partial, and open to objections. Thus, though the 75 per cent grant 'equalisation' was an attempt to unbias selection of alternative transport investments, why 75 per cent and why grants for capital only? Probably, one answer is that there was a feeling that economies of scale might be secured - hence the selection of a capital grant, with the implication that an incentive to gain passengers to fill the infrastructure would ensue. However we have seen reasons earlier to doubt economies of scale arguments in this context, and in any case to be realised, they would have required specific pricing rules to be imposed. The existing and wholly artificial distinction between capital and other types of expenditures on roads was reinforced by extending the same distinctions in public transport. (This is an interesting contrast to the railways grant system that we saw was established by the same Act - there, no such inducement to stress capital relative to current expenditure was built in.) But, of course, economic logic had, in the short run at least, to yield to financial reality. To remove uneconomic inducements, to encourage the consideration of alternative uses of funds, whether for investment, for subsidy, for current or capital expenditure or as between modes of transport, and thus to create a strong interest in setting up cost-benefit studies to guide the allocation of funds, would have required extensive budgetary reforms. As things are, there is no direct budgetary connection between these alternative uses of funds at the urban area planning level, and until that occurs it is probable that progress in the rationalisation of subsidies will be limited. In the United Kingdom at least this is one of the more urgent problems facing local government reform.

XII. Innovation and Subsidies to Urban Transport

At several points in this paper, it has emerged that innovation in urban passenger services is a desirable supplement, in terms of prospective net benefits, to the subsidy of existing forms of services; it may often, we have argued, be more effective to serve identified needs. A government may be able to delineate new services and provide inducements by subsidies to create their supply, but it must rely for the most part on the efforts of the 'industry' itself, as presently or prospectively constituted. (Here 'subsidies' means those to services provided by operators; technological development may of course be helped by subsidies designed to encourage it, but as pointed out earlier, the analysis of this, as it requires the exploration of the cost-benefit analysis of government support of research and development, lies outside the scope of this paper).

In considering the problem of creating favourable conditions for innovation, the division between a monopolistic and competitive supplying structure is still relevant. In terms of the type of innovation to be encouraged, we may usefully, if crudely, distinguish between services of the same general type as existing services but requiring some recombination and application of the use of assets and labour forces ('product variation'), and those which involve the acquisition or hire of new assets and labour forces or practices ('new products'). We thus analyse innovation by a two by two classification of innovation type and industry structure.

Taking first a monopolistic supplying structure and product variation, the necessary and sufficient conditions for increasing innovation seem to be for the government to ensure that the innovatory activity is regarded by a profit which recognises the operator's opportunity cost of inputs and risks. These include not only resource costs as ordinarily understood but also the necessary executives' inputs. At least the reproducible costs of an innovatory service must be in prospect; management time must be directed to the dividing of the services, and moreover, to projects which may be rejected on social-cost-benefit grounds by the government (which is presumably more expert in this kind of analysis, but which needs a constant supply of new projects for appraisal). The arrangements between the B.R.B. and the United Kingdom Government, as discussed in the previous section, recognise (and quite rightly) most of the elements here - including, as we saw, replacement cost depreciation and an allowance for administrative costs involved in grant applications. Margins must not only reflect full opportunity costs however; there must also be a risk (or more strictly uncertainty) premium because of the positive chance that services will be discontinued. (Social cost-benefit analysis on which the acceptance by the government of a proposal is based is still particularly subject to amendment and revision over time.) This last point is of especial importance if, as I believe, it is correct to think of executive input as an investment. Too little talent will be allocated to socially necessary services if the prospective rewards are inadequate.

The problems which we noted in the last section of the development of the relationship between the government and the operator still apply. A government may well find itself increasingly on the horns of a dilemma. Innovations will be successful, or not. If they are, a government will be under pressure to increase the apparent control of realised profits perhaps in the interests of reducing total subsidy outlays; if not, an added spur to intervene in more detail with the operator's affairs will ensue. The best hope of a continuing flow of innovatory projects in these circumstances is that the socially subsidised part of the undertaking's activities remains small relative to its total activity. There are interesting alternatives here: a government may, for example, alter the rules governing a nationalised industry's commercial actions, thus increase its general commercial scope. But these are speculations, again, outside the scope of this paper.

In respect of 'new products' and a monopolistic supplier structure, the points just made are reinforced by the consideration that, so far as innovation is concerned, existing investments in conventional assets and established labour practices are a considerable handicap. This is not, I believe, so much a case of straightforward attempts to preserve existing asset values, job types, etc., as a question of the perception of the possibilities for innovation, and this does mark a distinction with product variation, where constraints to perception are by definition less important(1). Radically new ways of thinking are hampered; one starts with the bias of using or recombining familiar constructs. To offer subsidies for services may then be positively harmful;

(1) It will be instructive to see how the Passenger Transport Authorities and Executives and like bodies in England will compare in this respect; for they have, together with the responsibility for initiating new forms of transport and small transport planning responsibilities, a ranging investment in conventional bus systems.

and to try to direct choice in the 'right' direction by tying subsidies to specific new technologies to be adopted by operators is probably hardly less disfunctional, for it implies a 'superior' knowledge by government which often, in fact is much less informed of market realities than is the operator's. In practice, of course, monopolistic operator structures are inevitable only where high volume radial rapid transit operation is required. Fortunately, perhaps, the most needed innovations in urban areas are, we saw, flexible aids to personal and diverse movements (i.e. a close as possible substitute for car trips).

A competitive supply structure does not, in principle, carry the disadvantages just noted. But here we must make a further distinction, concerned with the meaning of 'competition'. Clearly we may mean, broadly, the very many homogeneous firms characteristic of a theoretically purely competitive industry, or we may mean a structure composed of many rivals, actual or potential, but not necessarily homogeneous. In contra-distinction to most industrial situations to which economic concepts are brought, the transport industry indeed could conceivably boast a purely competitive structure in at least an important part of its operations - i.e. buses. But if the industry _were_ purely competitive, we could of course not point the way to encouraging conditions favouring innovation, because the structure lacks the necessary inducements to entrepreneurs. We are rescued from this by the fact that the bus industry is, potentially, very competitive in the sense of having cost conditions which favour the existence of many rivals; but it _is_ capable of product differentiation.

For our present purposes, the important point here is the word 'potential'. Restrictions on competition in fact abound. Many bus operators are monopolistic in structure for important urban areas simply because of the operation of licencing laws or by virtue of the granting of local monopoly franchises. Releasing these constraints is, in my view, a necessary condition for increasing innovation, but would it be sufficient - especially in respect of 'new products' rather than 'product differentiation'? The answer here lies in the combination of circumstances that first in the product range between large bus operation and the individual car and taxi lie most of the needed new products and that second, the existing bus operator structure is maintained at an artificially large scale. Were the constraints, or legal barriers to entry lifted, we could expect considerable increases in the kinds of services offered at both ends of the spectrum. Would prospective competition be so active as to inhibit a major new form of activity - such as a dial-a-bus system?(1) This seems unlikely, so long as some economies of scale are required, as indeed is implicit in any system which relies on a central information capability. However, even though there is some risk that allowing greater competitive freedom will fail to produce the most useful results in terms of its objective, a government would be wise to take what little risk there is in such a course of action. Decisions can be reversed at fairly low cost, and regulation is a simple matter to apply if the results are deemed unwelcome.

The part played by subsidies in this scheme of things seems to be as follows. Much of the difficulty that urban public transport has encountered in the last few years stems from its labour-intensive character. This is, of course, particularly true for bus services, and the reaction of operators has been to attempt to cut down labour inputs as with the very wide scale movement towards one man bus operation, and simplification of fares structures (to save collection costs). Without a concomitant effort to define and rebuild markets this has often accentuated losses of bus passengers. The effect of subsidising to counter labour cost increases would, in the absence of lifting restraints on entry, probably be to reinforce the difficulties - often compounded by established trade union agreements to working practices - of developing new markets. In this connection it is important to emphasise that public transport is not in universal decline: there is one area at least in which it is growing quite rapidly. That is of course the taxi and hire-car part of the industry. In the London, Metropolitan Area, for example, the number of taxis in service reached a post-war lowpoint in 1954; over subsequent 5 year periods the numbers increased by 7 per cent; 23 per cent and 9 per cent; and alongside this was an unmeasured but probably large growth of the close substitutes - 'mini-cabs' - a growth sufficient to play a part in stimulating a Government enquiry,

(1) This is an example of a class of 'demand-actuated' bus systems, i.e. where customers specify required trips and times. Several varieties have been named - e.g. Taxi-bus, DART, GENIE and CARS, cp. Kain and Meyer, op. cit., p. 85.

reporting in 1970(1). Thus, the <u>most</u> labour intensive form of public transport has been able to overcome the rising costs - even without effectively any change in its production function, though there has probably been also a steady relative growth of these services in the suburbs, yielding easier running conditions on average.

Several points about this experience should be made. The London taxicabs make what is probably a very rare instance of a combination of strict entry qualification operated entirely without restriction on numbers. Fares are controlled, and play their part in inducing or discouraging entry, of course, but in general this has simply been operated to follow cost changes. The increase in numbers is due principally to a shift outwards in demand, inducing more entrepreneurs into the trade. The average size of firm in the taxicab trade itself has been falling on average as this has proceeded. One taxi firm owned 45.7 of all taxis in 1969 as against 27.5 on average in 1938 and 37.0 per cent in 1950; the 'medium' sized firm 1-20 cabs has also recently been growing at the expense of larger firms)(2). The trade, given: its service characteristics in part by the strict requirements for highly specialist equipment (the top hat can still be worn while riding!) and the 'knowledge' of London by the labour force - which takes on average a year of intensive travelling about London to acquire, has withstood the competition of the near substitutes, whilst itself growing - evidence perhaps of the strong economic needs for differentiation of personal trip-making services. It would indeed be very instructive to compare in detail the experiences of different taxi-control and regulation systems, taking perhaps an international cross-section, to test formally the hypothesis that the London type freedom of entry has led to a greater relative growth of services(3). Meanwhile it seems at least plausible

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(1) The report of the Departmental Committee on the London Taxicab Trade: October 1970, Cmnd 4483, H.M.S.O., Cn. p. 35, p. 50.

(2) Op. cit.: also Table 4(2), p. 39.

(3) Kain and Meyer, op. cit. p. 86, point to the fact that in Washington, D.C., which has an 'essentially' unregulated taxi trade, has a greater number of taxis per person than other cities in the United States, in which regulation produces a considerable monopoly value for the rights.

that the apparent adaptability of the trade in London to changing demands has some positive connection with that freedom(1).

At the other end of the (road) public transport spectrum is often, as we saw, subsidised and conventionally oriented bus operation. The filling of the market gap between a commercially viable high quality and highly labour-intensive service and the subsidised operations requires, one would predict, considerable flexibility in the use of labour - for example, the widespread use of part time labour combined with much smaller buses, perhaps centrally controlled, for peak hour or other peak leisure time operation(2). Subsidised operation clearly diminishes the prospecive profitability of such innovations, depending on their competitiveness with the subsidised operations. Resistance to substitution at the 'conventional' end would be, one imagines, particularly strong because of the threat which use of labour will pose to full-time jobs in that sector. From the point of view of promoting innovation, therefore, there seems to be a case for redistributing any existing subsidy towards amelioration of the personal consequences of technological change: generous redundancy pay and facilities for retraining seem to offer the best hope for using subsidy to good effect in this area. But the overriding need is for reform of entry controls: there are opportunities for growth still in urban public transport which, if allowed to manifest themselves will attract those new entrepreneurs and managerial skills so widely admitted to be essential to the future well-being of public transport and yet so difficult in practice to muster.

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(1) Major restrictions on the use of private cars for carrying passengers of course remain, as does the bus monopoly. The taxi trade could probably well cope with the relaxation of both.

(2) Kain and Meyer, op. cit., p. 86, point out that in Washington, much part-time operation and doubling the use of taxis for the drivers' own families exists.

APPENDIX 1

THE MACRO-ECONOMIC ARGUMENT FOR URBAN TRANSPORT SUBSIDY

So far as I am aware, no attempt at analysing fully the case for subsidy in terms which incorporate predicted effects on general employment and price changes has been attempted. A most interesting partial attempt occurred with the United Kingdom's National Board for Prices and Incomes' (P.I.B.'s) analysis of a proposed fare increase for the London Transport Board - L.T.B. - in March 1968(1). (This was at a time when an attempt was being made to restrain prices and wages increases by reference to P.I.B. for investigation and subsequent action by responsible Government Departments). The issue was posed in the P.I.B.'s report as a trade-off among the following possibilities - a general or selective tax increase, the latter bearing on short-distance passengers or bus and tube passengers separately, thus potentially breaching the policy of uniform fares per mile for all passengers in London; or a subsidy from the Government to L.T.B. (an increase in the existing deficit). The report considered, and very sensibly, the congestion losses (via diversion to roads) that rises in passenger transport fares would provoke and, on what it admitted to be very shaky evidence, concluded that the congestion losses might just exceed a possible subsidy to bring L.T.B. back to break even. This was, in fact, a first attempt to analyse the problem in a cost-benefit framework. There were, of course, considerable limitations to its scope which were imposed by difficulties of finding data and, more important, the very short time allowed for analysis. Thus, few alternative pricing solutions which might be open to L.T.B. were considered; and external prices, e.g. taxes on competitive roads were considered fixed. These, in themselves, were

(1) Proposals by the London Transport Board and British Railways Board for Fare increases in the London Area (Cmnd. 3561), March 1968.

reasonable assumptions for the problem at hand; both internal and external prices require a long time for substantial restructuring. In any case, the time horizon for discussion relating to the management of inflation in an economy is necessarily short, and measured in quarters rather than years. But the report rightly raised, but did not analyse, the question of the effect upon management efficiency of abandoning the principle, hitherto only very slightly compromised in London, of requiring a balanced budget in L.T.B.(1). This might be viewed as a casualty of the time constraint.

In short the approach was limited so far as impact on micro-economic variables are concerned. What was missing, and so vitiated the attempt, was a serious analysis of the inflationary consequences of the options. On the one hand, a decision to allow a fare rise was assumed, without discussion, to be inflationary - on the score that wage demands would be stimulated thereby. But one might have expected, at the very least, some consideration of the facts that fare rises in an area like London (when 90 per cent of passengers who commute to the centre do so by public transport) could be, as commentators have often pointed out, similar to a poll-tax in its effects - a highly regressive, direct diminution of disposable incomes. This effect, in itself, might well be expected to be deflationary - and certainly so compared to many other conceivable forms of price increases. Offsetting this effect would, of course, have been effects on wage claims via cost-of-living index increases, but this again would have depended on the composition, and affiliations, of commuters, thus requiring some analysis of how precisely a fare rise enters into wage or salary claims. (Thus it could be argued that organised salaried workers until very recently have been relatively poorly organised from a traditional union viewpoint, and even now probably contain a very high proportion of workers whose wage claims follow rather than lead wage movements elsewhere).

Along these lines, one might have been able at least to delineate the likely inflationary 'gains' or perhaps 'losses' from avoiding a fares rise in this particular case as they might

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(1) L.T.B.'s first deficit occurred in 1966. Its receipts in 1966 were £103 million; it received £3.8 m. 'compensation' from the government for the embargo imposed by the Government on fares increases. Cn. Annual Report 1966, L.T.B. Annual Report and Accounts, 1966. P. 58.

have affected commuters adjustments. On the other hand, if a subsidy were to be contemplated a series of questions about the raising of the tax burden at the margin and its treatment by the Treasury would have arisen, calling in question the Treasury's options. These points, quite essential, with perhaps others, to an assessment, were ignored in the report. The reason to be given for this failure to deal realistically with inflationary factors must be speculative; but perhaps the leading ones concerned the P.I.B.'s strategic relationship with government. At that time, the P.I.B. was (perhaps rightly) committed in <u>general</u> and publicly to the proposition that inflation in the United Kingdom was cost-based. It may well have deemed it unwise to appear to challenge its own general posture and therefore threaten its effectiveness, by opening up the possibility - from an inflationary point of view - of benign price increases. Similarly, no doubt it seemed that a Pandora's box would have been opened up by any serious examination of Treasury options, with possible implications critical of the management of the economy.

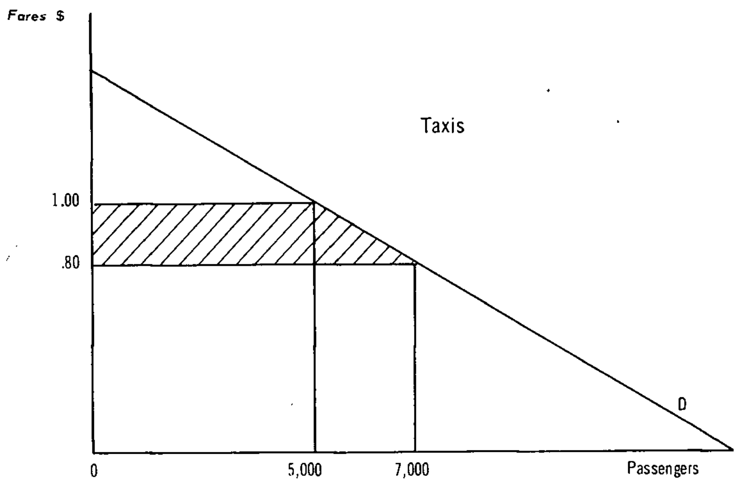
The broader implications of this history, however, seem to be that because of the necessarily different time scale for analysis and the need for speedy decision-making, one cannot at present seriously entertain a cost-benefit analysis of a public transport subsidy as a counter to inflation which attempts to include predictions of the effect on micro and macro factors. The problem is that one can never avoid facing the micro factors, for they are palpable and important to the relationships between the parties involved, a commital to subsidy <u>does</u> affect the way in which public transport is run. Yet these effects are often more important in the long term, so here it often makes sense to consider subsidies only if the long view is integrated with the short. The macro view not only introduces extra complications of analysis and integration with other policies but is essentially part of a problem of the short-term management of the economy. For this the requisite analyses in depth are hardly feasible in the time scale available. Certainly, the prospect of being able to develop well argued grounds for approving or disapproving a public transport subsidy on macro-economic grounds seems at present rather dim. If and when short-term forecasting models of the economy are available at the requisite level of disaggregation and are accepted as useful tools for policy analysis, the grounds will become much firmer.

APPENDIX 2

THE 'EQUAL SUBSIDY' ILLUSTRATION (1)

As stated in the text, strictly it is impossible to compute the gains in surplus to taxi and bus users from the data given in Fitch et al's example. An alternative computation follows, which applies the arguments of Beesley & Walters (2) to the calculations of consumer surplus where price changes on competitive modes are in question. Additional assumptions are made where necessary to supplement the Fitch et al data.

Option 2. This can be estimated simply by selecting the taxi mode for analysis. The price of taxis falls: extra passengers shift from buses. The following diagram illustrates the calculation.



The demand curve for buses also shifts, as a result of the price cut on taxis, but this is not needed for the calculation, which is entirely measured by the shaded area in the diagram. Assuming a straight line demand curve, the change in consumer surplus is:

$$500 \times \$ .20 + \tfrac{1}{2} \times 2000 \times \$ .20 = \$1,200$$

This result is identical to that of the text.

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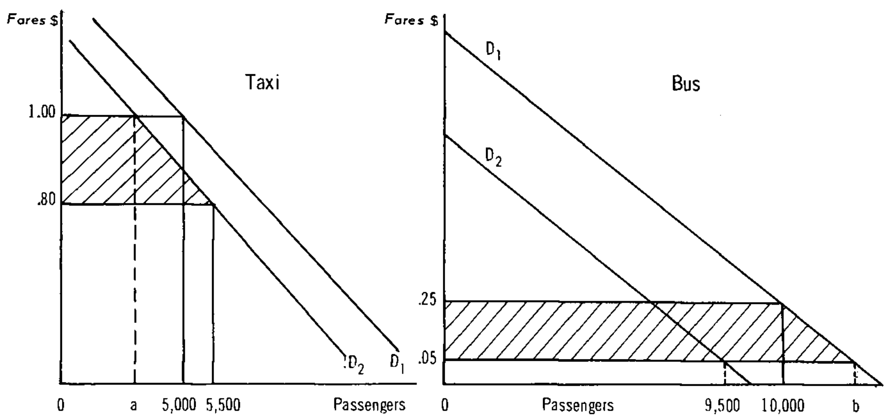
(1) I am indebted to Miss Sally Holtermann for the computations in this Appendix.

(2) M.E. Beesley & A.A. Walters: Some Problems in the Evaluation of Urban Road Investments. Applied Economics Vol.1 N°4 1970 pp. 241-259.

Option 3.

Here both prices change, and so both modes experience a shift of demand curves. The fares and quantities on each mode before and after the changes are given.

The position can be shown as follows:



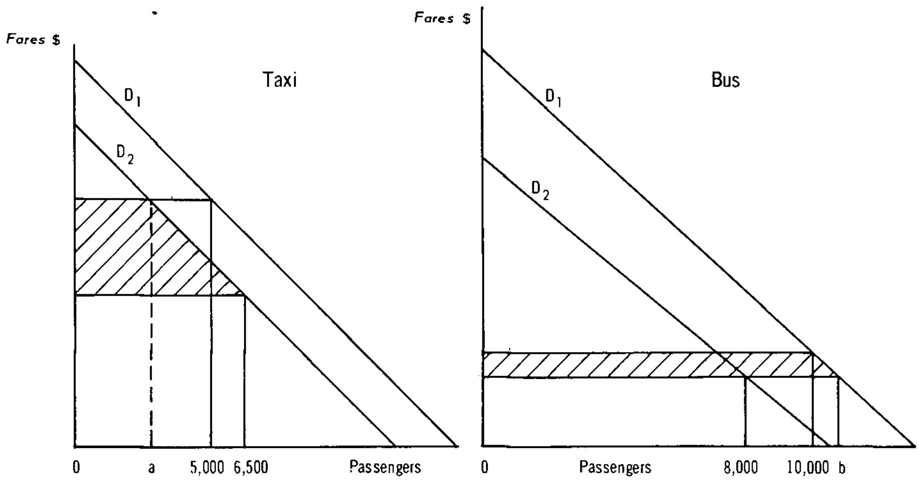
D_1 in each case represents demand before the changes; D_2, demands afterwards. The gain to be measured is the shaded areas. We take first the bus fare change, with taxi fares fixed, computing the gain as marked. This price change shifts the demand curve for taxis to D_2, whose fare is lowered. This gives the second shaded area (1). This procedure requires estimates of a & b. a is estimated by assuming it lies on a straight line demand curve of the same slope as the demand curve defined in option 2 above; b is estimated by assuming that it lies on a straight line demand curve of the same slope as that defined for option 5 below. Then a = 3500 passengers and b = 11,000 passengers. The change in consumer surplus is:

$$\$3,500 \times \$0.20 + \tfrac{1}{2}(2000 \times \$0.20) + 10,000 \times \$0.20 + \tfrac{1}{2}(1000 \times \$0.20) = \$3000.$$

The taxi fare charge also shifts the demand curve for buses to D_2. This does not affect the measure.

(1) As shown below, we could have started with either mode, with the same result.

Option 4.



Similar assumptions have to be made in the above.

a = 4,500 b = 10,250 passengers.

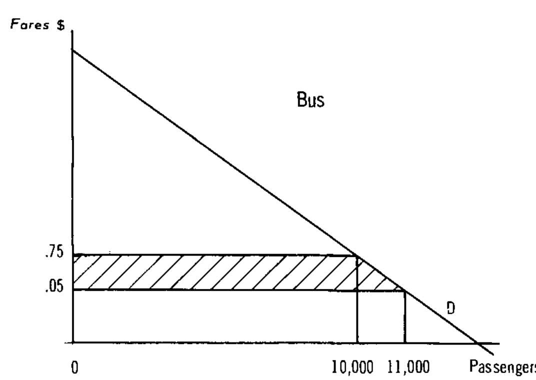
The change in consumer surplus =

$ 4,500 x 0.20 + ½(2000 x 0.20) + 10,000 x $0.05 + ½(250 x $0.05)

= $ 1606.25

Option 5.

This may be estimated by reference to buses only, as the price change affects that mode alone.



The change in consumer surplus =

\$10,000 x 0.20 x ½(1,000 x \$0.20)

= \$2,000 + 100

= \$2,100

This result is the same as in the text. The results for options 3 and 4 here are close to the text calculation, which may be viewed as an approximation for a fuller analysis.

The underlying argument of this method is as follows. The price changes from $(p_1^a p_2^a)$ to $(p_1^b p_2^b)$ can be split up into two separate steps: from $(p_1^a p_2^a)$ to $(p_1^b p_2^a)$ and from $(p_1^b p_2^a)$ to $(p_1^b p_2^b)$. The changes in the Marshallian measure of consumers' surplus resulting from each step are the shaded areas in the diagrams below. The overall change in consumers' surplus is the sum of the areas. The order in which the price changes are considered is irrelevant for the simple types of functions assumed here.

APPENDIX 3

EFFECT OF WITHDRAWAL OF A SPECIMEN BUS SERVICE
SOCIAL COST BENEFIT ASSESSMENT - MEASURABLE ITEMS

+ = Increase in benefits or reduction in costs
- = Reduction in benefits or increase in costs
All figures relate to £'000 per annum to the nearest thousand

	London Trans-port	British Rail-ways	Local Author-ities	Central Govt.	Users of with-drawn bus service	Users of roads and parking space indirectly affected by with-drawal	Change in social costs and benefits
	A	B	C	D	E(k)	F(k)	G
Withdrawn bus service							
1. Value to users					-63		- 63
2. Revenue	-40				+40		0
3. Cost effect	+68			- 1(a)			+ 67
Other bus services							
4. Value to users					+10	+ 1(b)	+ 11
5. Revenue	+11				-10	- 1(b)	0
6. Cost effect	nil						nil
British Railways(c)							
7. Value to users					- 3	+ 1(d)	- 2
8. Revenue		-2			+ 3	- 1(d)	0
9. Cost effect		nil					nil
Road users							
10. Value to users of withdrawn bus diverted to car					+52		+ 52
11. Cost to users of withdrawn bus diverted to car				+ 9(e)	-52		- 43
12. Congestion				+10(f)		-120	-110
13. Value to car users diverted because of increased congestion						- 5	- 5
14. Cost to car users diverted because of increased congestion				- 1(g)		+ 5	+ 4
Parking(h)							
15. Value to users					+10	- 2	+ 8
16. Revenue			+8		-10	+ 2	0
17. Congestion						- 2	- 2
Other considerations							
18. Change in indirect taxation receipts on non-transport expenditure(j)				- 4			- 4
Total	+39	-2	+8	+13	-23	-122	- 87

For text of footnotes see page overleaf.

NOTES TO APPENDIX 3

General: In the case of columns E and F it is to be noted that there are several pairs of adjacent rows with equal figures but opposite signs, e.g. in column E, rows 4 and 5 show respectively the benefit of £10,000 per annum that former users of the withdrawn bus service enjoy from the other bus routes to which they divert and the money cost of £10,000 which they pay for using these services.

(a) Reduction in government revenue from taxation of bus fuel.

(b) Relates to other people who divert from car to bus owing to the increased congestion on the roads.

(c) The specific section of bus route withdrawn feeds a rail head in the suburban centre which caters for a substantial number of peak period commuters. Therefore following withdrawal of this particular section of bus route there would be a reduction in the number of people travelling by rail from the rail head in question. There is no rail service which passengers can use as a substitute for the withdrawn bus service in this case.

(d) Relates to other people who divert from car to rail owing to the increased congestion on the roads.

(e) Tax on petrol consumed by users of withdrawn bus service who now travel by car. Note that if this figure can be calculated directly, the introduction of the £52,000 and £43,000 is unnecessary for the analysis. They are included here only in order to make the logic clear.

(f) Of the extra time costs and running costs imposed on other road users by the additional car traffic, £10,000 constitutes extra fuel tax revenue.

(g) Loss of fuel tax revenue from previous road users now diverted from the roads owing to the increased congestion (cf. (b) and (d)). Here too, the £5,000 and £4,000 only enter into the final result by difference but are included to make the logic clear.

(h) In this particular case there would be enough parking space for commuter users of the withdrawn service who shift to travelling by car. The displacement of existing users is due to the extra road congestion on weekdays and the parking congestion is due to an excess demand for parking space confined to Saturdays in the suburban centre.

(j) Travellers will spend more on travel by public and private transport combined after withdrawal of the bus service than they did while the bus service still operated. Assuming the same level of savings, they will therefore spend correspondingly less on other personal consumption, with a consequent reduction in indirect taxation receipts to the Government. The average rate of indirect taxation for all personal consumption has been assumed to apply to this reduction in consumption of non-transport items.

(k) Where figures are shown in both columns E and F in any one row and also in rows 10 and 11 on the one hand and 13 and 14 on the other, the split between columns E and F is unnecessary for the analysis. All these figures cancel out in the column totals, and they do not of course affect the overall estimate of social loss. They are included here only to make the logic clear. The split between columns E and F in these cases should be regarded as illustrative only. Further research would be necessary to determine firm quantitative estimates of the allocation between the two columns.

For example, the basic figures necessary for the analysis as regards railways are shown in column B rows 8 and 9. These show a net loss of £2,000 per annum in the "producers surplus" for British Railways. Columns E and F (row 8) show users of withdrawn bus services and users of roads respectively saving £3,000 by shifting away from railways and spending £1,000 more by shifting to railways. This latter figure arises because some original motorists are diverted to railways due to increased road congestion. Row 7 (columns E and F) cancels out with Row 8 (E and F) by showing the benefit foregone or secured corresponding to the extra money saved or spent.

Source: National Board for Prices and Incomes. Report No. 159. London Transport Fares. Nov. 1970. Cmnd. 4540. HMSO.

TOPIC II

ECONOMIC CRITERIA
FOR THE MAINTENANCE, MODIFICATION OR CREATION
OF PUBLIC TRANSPORT SERVICES
WHICH MAY NOT NECESSARILY BE PROFITABLE

2nd Part

TRANSPORT OUTSIDE TOWNS
(Passengers and Freight)

P.H. BENDTSEN and Tom RALLIS
The Technical University of Denmark
Department of Road Construction,
Transportation Engineering and Town Planning

SUMMARY

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INTRODUCTION

Northern Norway is a very extended but narrow country with few inhabitants. The area between Trondheim and Bodø was until the beginning of the century only served by sea transport. In the beginning of the 20th century, a road between the two cities was constructed, and later connection by airplanes landing on the sea was also introduced.

It was felt, however, that the fourth means of transportation, the railroad, was also necessary, and a railway was opened to Bodø about 1950.

One of the reasons for the construction of the railway probably was that it is more certain to be functioning during winter time than the road, as it is easier to clear the snow away on a railway, than on a road.

This example shows that there has been a tendency to serve regions, even with small population, with all four kinds of transportation. However, in the meantime, the air transport in northern Norway has been very much improved with planes landing on airports, and consequently passenger transport by ship is now decreasing.

Inland water transport was developed to a high degree in Great Britain and on the continent in the beginning of the 19th century. With the coming of the railways many canals, especially in England, were closed down, but inland water transport found its domain and now-a-days a lot of goods are carried on water ways in Europe. This should be kept in mind when considering the future of transportation.

The necessary criterion to determine whether a subsidy should be paid to an unremunerative transport facility is that it should be provided, if there is a net present value of social benefit, after discounting at the current rate, and in absence of financial restraints.

However calculation of the benefits in a monetary form and of the real costs in operating including external costs and then to project these factors to the planning period is not simple. The pricing policy poses another difficulty.

As an example, the Danish Academy of Technical Sciences some years ago investigated the question of traction on the Danish railway and consulted two experts. The operating costs for electric traction and diesel traction, suggested by these two experts, were rather different.

The difficulties in getting the constants should, however, not keep one from setting up transport economic calculations. An attempt will be made in the following chapters.

The various persons and bodies involved in transportation will also have different views of what an optimum service is.

The operator of a system may choose as his optimum the system which optimises the profit of his company.

The customers may think the best service is the most reliable, comfortable and quickest.

The community may find the optimum service the one which has the lowest noise level and air pollution, and demands the least area in the city.

Transportation engineers may think the facility, which caters for all passengers in peak hour without congestion, is the best.

The non-vehicle drivers, be they young, old, poor or handicapped, may find the public transport which can give them the cheapest service, or service at all, as the optimum.

In this paper, chapters I and II give an outline of transport characteristics and of transport models. In the following chapters, the transport problem is dealt with in three sections, the Intercontinental, the European, and the Danish transport networks and the criteria and constants found in chapter I are used to decide whether closure, improvements or new systems would be the right solutions.

I. TRANSPORT CHARACTERISTICS

A. CAPACITY

Below are given some technical facts about the various transport modes; for comparison averaged figures are presented.

Passengers per traffic unit

Looking first on sea transport, a boat from Great Britain to Australia carries 1,700 passengers and the boat between Copenhagen and Oslo carries 1,000 passengers.

A railway train with 13 cars of 80 passengers also carries about 1,000 passengers and a jumbo jet carries 300-400 passengers; it is remarkable that the number of passengers by jumbo jet is now nearing the capacity of a train. An intercity bus carries may be 50 passengers and a helicopter approximately 25.

Freight per traffic unit

The weight of 300 containers in a container boat is about 6,000 t. Containerboats are now planned with 3,000 containers with a weight of 60,000 t.

A goods train on the Danish state railways may have a weight of up to 1,200 t. of which about 800 t. will be the weight of the goods. In the United States, goods-trains carry 3,000 t.

A big truck with trailer may carry 40 t.

Running speed

The speeds indicated below are running speeds from station to station or from airport to airport and do not include the time to come to station and airport. This question is discussed on page 104.

The Copenhagen-Oslo boat mentioned above has an average speed of 35 km/h.

The running speed of railways has been increased in recent years, the permitted maximum speed on some lines has been increased to 200 km/h. For the Japanese Tokaido line even to 210 km/h and for the extension of these lines to 260 km/h.

As exaples the average speed on the Paris-Bordeaux line (580 km) without a stop is now 138 km/h and on the Tokyo-Osaka line (515 km) with 2 stops 165 km/h. On the Danish line Copenhagen-Korsør (110 km) it is 108 km/h (without a stop) (see page 141.

It should be mentioned that there is a possibility of increasing the maximum speed of existing railways. If a new pendulum suspension for coaches is used trains can run with a maximum speed of 200 km per hour in a curve with 1,100 m radius. For an ordinary train the curve radius must be 2,200 m if it shall run with the same speed.

The speed of buses and cars on motorways depends on the number of cars on the road and the service level. Maybe one could reckon as 80 km/h. average speed.

For the moment speeds for aircraft are between 800 and 1,200 km/h going up to 2,000 km/h for supersonic (1)*.

Capacity

In a thesis at the Technical University in Copenhagen (2) the traffic of the single track line from Vordingborg to Rødby was simulated on a computer, and it was found that with 6 trains in one hour the delay for each train passing on the line would be 4½ minutes. With a rush hour traffic of 10 per cent of the 24 hour traffic the single track line according to this calculation should have a capacity of 60 trains per day. Usually single track lines do not take more than 40-50 trains per day.

For a double track line the capacity per direction is often reckoned to be 100 trains per day. With a rush hour traffic of 10 per cent you get 10 trains per direction in the rush hour. A calculation carried out by the use of queueing theory (2) gave as a result, that with 12 trains per hour there will only be a delay of about ½ minute per train. If each train carries 1,000 passengers that means that a railway line can carry 12,000 passengers per track per hour i.e. 60 million passengers or 60 million t. freight per year.

A motorway carries 1,000 cars per hour per lane (service level A). With 3 lanes per direction it means 6,000 cars or 3,000 trucks in both directions. With 10 per cent rush hour traffic we get 60,000 or 30,000 trucks per day. Per year one gets

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* ( ) For references see annex.

theoretically 18 million cars or 9 million trucks. With 1½ persons per car one gets 27 million passengers a year. Usually the truck per cent is 10, so 9 million t. per year (with 10 t. trucks) plus approximately 24 million passengers per year is normal capacity.

Inland waterways can handle approximately 12 million t. per year.

Pipelines can handle 30 - 60 million t. per year depending on diameter and material transported.

For freight it is most remarkable to see that the pipeline has a capacity of 2 - 4 times canal transportation.

Normally the capacity restraint for ships and aircraft is at the terminals. As it is impossible to accurately schedule arrivals and departures.

The port traffic capacity for ships depends on ships time in port so that containership berth capacity is 2 million t. per year, whereas non-container ship berth capacity is only 0.1 million t. per year.

A port with 6 berths for containerships has a capacity of about 12 million t./year.

The airport capacity is normally taken as runway capacity i.e. 40 aircraft per hour, 400 per day and 120,000 per year which means that an airport with only one runway can take about 12 million passengers/year or 12 million t./year (Jumbo jets).

B. TECHNICAL COSTS

1. Construction costs

E.E. Marshall (1) gives the following information concerning construction costs per mile of line:

	Construction costs: £ per mile (Great Britain 1968)
Canal(*)	£1 million
Two track railway	£0.75 million
4-lane rural motorway	£0.5 - 0.8 million
Pipeline (depending on size)	£0.035 million
Sea and air(**) traffic	

(*) The canal mentioned has a width of 55 m at water level and at the bottom 31 m, and the depth is 4 m. This type of canal is able to carry vessels of up to 1,350 t.

(**) Navigation equipment associated with the sea and airway system are Loran, Consol and Decca stations and Radar. The first one costs about £1 million per station, the others are less expensive.

It is seen that the construction cost for a two track railway and a 4-lane rural motorway is about the same per mile, whereas the canal described is 30 per cent more expensive. It is also seen from the table that construction of a pipeline is only about 3 per cent of the cost for the canal.

Concerning terminals, Marshall mentions that a harbour berth costs about £2.5 million including equipment. For a class B airport, average capital cost is about £10 million.

2. Operating economy

The weight/drag ratio is of importance for the operating costs of the various transport modes.

One of the more important characteristics of ships is their very low installed power, only between two and three horsepower per ton displacement. This implies a weight/drag ratio of 100 to 200 by 20 - 30 knots. There is, however, a very large increase in drag with increasing speed. The combination of low power and high payload means that the operating costs of large cargo ships and oil tankers are very low, typically less than 0.5 pence per ton-mile. New types of vessels, such as air cushion vehicles and hydrofoils have higher cruise speeds, 50 to 70 knots, but this is with a very large drag penalty and hence large amounts of installed power are required. The weight/drag ratio is of the order of 10.

The weight/drag ratio of aircraft is at the actual speeds about the same as for hydrofoils from 10 to 15.

The weight/drag ratio for a train is lower than for a truck which means that the pure traction costs for the same ton mile will be lower by railway than by truck.

It has hitherto been accepted that one of the main advantages of inland waterway transport over railway transport is the lower energy expenditure involved. However, Breimeier (3) showed recently by means of motion-dynamic investigations, that this is not so, and that freight transport by water and rail requires about the same expenditure of energy, so that superiority of inland waterway transport over rail transport in this respect does not exist.

It should also be mentioned here that Fülling (4) proved recently that the anticipated rate of return of building the Rhine-Main-Danube Canal link will be approximate minus 10 per cent (see page 96).

Operating costs

For the figures given below also E.E. Marshall (1) is the main source. These are average costs in England 1968. The figures can vary considerably with type of vehicle, road, utilisation and wage rates, etc. The cost of licences and taxation is included. Cost of pipelines varies with throughput, line diameter and pumping pressure.

	Operating costs d per pass. mile	Operating costs d per t. mile
Sea	0.5 pence	0.1 - 0.5 pence
Railway	1-3 -	1 - 5 -
Bus - private car	1-8 -	
Big truck - Small truck		1 - 5 -
Air	3-6 -	-
Pipeline	-	0.25 -

Fares and rates charged by transport operators vary with distance travelled, capacity and type of service. See page 131,132.

For aircraft on long distance routes the operating cost is about 1 penny per passenger mile, and for short range aircraft the operating costs are about 2 pence per passenger mile, if the aircraft is full. Taking into consideration the usual load factor it will be more correct to reckon with 3 pence per passenger mile for long distance route and 6 pence per mile for short range aircraft. The comparable cost for railways is 3 pence per passenger mile.

Air is cheaper than rail for low traffic volumes less than 2 million passengers per year and longer haul routes more than 500 statutory miles. The calculation is based on a cost of 3 pence per rail passenger mile and 6 pence per air passenger mile and no value on time saving. See page 145.

The percentage of operating costs that vary with traffic is for rail and air only 25 - 50 per cent, whereas a bus service can have 80 - 90 per cent variable operating costs.

For situations where rail and sea distances are equal, rail costs for freight are always below those of ships with capacity of 600 containers or less (6).

For ships above 600 containers capacity, the break-even depends on the mileage involved.

For a 1,200 capacity ship, sea becomes cheaper for distances above 3,300 miles.

Similarly for a 2,400 capacity ship, sea is cheaper above about 1,900 miles.

At a distance of over 100 km and a capacity of about 3 million t. per year the pipeline is the cheapest mean of transport by land. A question which is very much discussed is how much the various modes pay of their infrastructure or track costs. Not very much research has been done concerning this question. One of the most well known is the AASHO test which concluded that costs for trucks varied as the fourth power of the axle weight.

Prof. H. Krauss (5) from Austria in a recent publication indicates that in Austria Trucks pay 40 per cent, railway freight pays 72 per cent, and Danube shipping only 2 per cent of the actual track costs including interest. Krauss assumes a linear relationship between axle weight and damage to the road surface.

For container transport in unit trains rates for a distance of 600 km are only 25 per cent to 40 per cent of conventional goods rates.

McKinsey (6) gives following rail cost in £ per container: 500 miles about £10 compared to road cost in £ per container 500 miles about £75.

It is often maintained that a train with 100 10 t. containers only needs two men for operation. If the same containers should have been carried on trucks, 50 trucks would be needed with a crew of at least 50 persons. It is remarkable that container trains currently in operation are on the move more than 80 per cent of the time, and they are achieving about 100,000 miles per year which is four times more than an ordinary goods waggon. Container transport in unit trains is a very advantageous form of freight transportation on railways.

There are investigations which give quite different results concerning manpower used by rail and truck. An investigation made in Norway in 1963 (7) maintained that use of labour per t. km on the Norwegian railways is about 6 times as high as comparable long distance transport by truck. As half of the labour force is used for maintaining railway lines, it actually would be more correct to use the factor 3 to 1 for railway contra truck. the comparison is also probably with rather big trucks.

It could be mentioned that the freight waggons on the Danish state railways, which can carry in total 250,000 t. perform 1,500 million t./km. a year. The Danish trucks can carry 350,000 t., but perform 10,000 million t./km. a year (8). The trucks then perform per t. carrying a capacity of 5 times as many t./km. as the rail goods - waggons. However the trucks carry much short distance city traffic, so comparison is difficult.

The whole question should be investigated further.

In Scandinavia one has but few investigations of the actual cost of freight transport by rail and truck. An investigation carried out in Sweden in 1959 (9) gave the following result:

Distances where rail according to Swedish experience is cheaper than truck transport

Number of trans-shipment truck/rail	Carrying capacity of truck		
	8 t.	13 t.	21 t.
0		all distances	
1	more than 50 km	more than 80 km	more than 200 km
2	more than 200 km	more than 250 km	more than 400 km

C. SOCIAL COSTS

1. Value of one hour time savings

One of the constants which it is most necessary to know when working with Cost-Benefit analysis is the value of one hour.

Below shall be mentioned two Danish investigations concerning that question.

The Danish road directorate (10) in 1970 gave the following recommendation for the value of 1 hour:

The national income was in 1968: 74 billion Cr. divided by 2.4 million gainfully employed inhabitants. One gets then an average income per employed of Cr. 31,000.

With 2,100 working hours per year, the average income per hour is 15 Cr. With 1.3 persons per car, one gets a value of Cr. 20 per car hour, if the persons in the car are "working".

By asking people driving cars on Danish mainroads the following was found:

Driving in "work" and "from home to work": 25 p.c. of all cars
Driving in "leisure time": 75 p.c. -

One then gets the following value of time for persons in cars calculated per car.

If leisure time is evaluated of 0 dkr: 5 dkr per car per hour
If leisure time is - - $\frac{20}{3}$ dkr: 10 - - - - -

For some newly constructed circumferential roads at Danish provincial cities it was, besides the construction costs for the road, found how many cars per yers, that used the circumferential road. It was also calculated how many minutes each car saved by using the new road instead of driving through the city (20).

For two of the new roads the following (11) values of 1 hour were obtained.

	Year after opening	Average of a twenty year period
Circumferential road at Lyngby	dkr 15.-	dkr 6.-
- - - Herning	- 57.-	- 10.-

For this it will be seen that the politicians who decided that the roads should be built, have actually reckoned with a value of one hour between Cr. 15 and Cr. 57 for the year after the opening, and between 6 Cr. and 10 Cr. as average for a 20 year period after the opening of the road.

2. Cost of accidents

The following table shows how dangerous the different modes are:

	Fatalities per 10^8 pass. miles
Ships	0.1
Railways	0.1
Busses	0.1
Cars	2
Air traffic (scheduled)	1

The table shows that it is 10 times safer to travel by ship and railway than by air, and it also shows that again it is twice as dangerous to use an automobile as to travel by air. (All in relation to passenger miles).

The cost of road traffic accidents is rather considerable. According to a Danish investigation (10) the cost per person - accident is 75 - 100,000 dkr (this includes also cost of accidents with no personal injury). One has 20,000 accidents with personal injury per year and about 1,000 fatalities. The total costs are then 1,500 to 2,000 million dkr per year. This includes both cost for repair of automobiles, hospital expenses and expenses to police which together is about half of the amount mentioned. The other half is loss to society on account of the injured being unable to work in a certain period. It is evident that transfer of traffic from road traffic to rail or air will mean a great decrease in the expenses to accidents.

3. Traffic noise

Some investigations have been made of the social expenses due to noise (12).

First, something is given about the expenses for reducing noise:

For a motorway a reduction in noise level of 30 dBA could be achieved by an additional cost of 0.05 million £ per km road (double windows).

A reduction in noise level of 5dBA could be achieved with a 3 m screen costing 0.03 million £ per km.

R.A. Waller has defined "Annoyance" as representing the percentage of people "annoyed" in a given situation.

Waller found:

Aeroplane noise	10 NNI(*):	Annoyance per cent:	8
-	-	50 -	- -	- 50

He also found a relationship between annoyance per cent and loss in value of adjacent dwellings (households).

For instance, 50 per cent annoyance produced a loss of value of £70 per household. Normally aircraft noise produced 60 - 70 per cent annoyance which gives a loss of £50 - 500 per household. (Fig. 1).

Installation of double windows as mentioned above should give an increase in "household value" of £0.06 million per "mile of houses".

Installation of the 3 m screen should give an increase in household value of £0.05 million per "mile of houses".

(*) NNI: Noise and Number Index. Number means number of aircraft per day.

4. Calculation of the economic development in a region caused by the construction of a new traffic line

In this calculation the expression 'demographic potential' of a town is used. The welfare of a society is anticipated to depend on the number of interactions per unit of time which the members of the society are able to undertake. If the town considered has a number of inhabitants P_i, the other towns in the region P_j and the distance between towns is d_{ij}, the demographic potential I_i is defined as:

$$I_i = P_i \sum \frac{P_j}{d_{ij}}$$

In a report from the Technical University of Copenhagen to the Road Congress in Tokyo 1967 (13) it was shown that there is a relation between the economic level of the city and its demographic potential. The report discussed two projects for a North-South motor road in Jutland one in the "middle" of the country and one following the cities on the East coast.

For all the provincial towns with a population exceeding 5,000, it was shown that the aggregate increase in annual income from model East amounts to dkr 245 million compared with 166 million from model Middle.

D. TRANSPORT COSTS IN INDUSTRY

A common dictum in transportation economics is that, if rates reflect costs, shippers will make modal choices which allocate traffic to the most efficient mode for given transportation requirements. The meaning of "reflect" is unspecified. Because of the large gap between average and marginal costs in the case of railways, it is unlikely that this dictum equals rates and costs. This cost-rate dictum represents an extreme oversimplification.

The movement component, including elapsed time of a shipment, packaging outlays, schedule frequency and reliability, completeness of the service, etc., is tied in with other components such as production scheduling, inventory control, packaging and storing. Failure to recognize the cost interdependence among components may lead to suboptimization.

The system view requires that movement costs be weighed against the effect which alternative modes of transport have in other components of the system.

The key is found in the effect which alternative transport have on total distribution costs: the non-transport costs. Truck has the advantage in overall distribution cost if the difference price (truck) - price (rail) $<$ Non-transport cost (rail) - Non-transport cost (truck) while shippers will presumably be attracted by lowest distribution costs, transport price plus non-transport cost; this sum does not necessarily measure the lowest real costs; these are measured by marginal costs plus non-transport cost (14).

Edwards (15) gives some interesting remarks in a discussion of the English census of transport cost in industry covering establishment engaged in manufacturing, construction, mining, gas, electricity and water. The extension applied only to the larger establishments, employing 25 or more persons, within the United Kingdom, normally for the movement of goods outwards only.

In 1963, the English industry mentioned spent about £1,000 million on transport, of which about £500 million was paid to other organisations, mainly road hauliers and the railways, and nearly £500 million was spent on own road transport.

For 35 industries, out of 128,the cost of own road transport is more than half the total transport cost. Three of these industries, gas - electricity-and water supply, are special cases because their products are carried by pipe or wire and their demand for other forms of transport is mainly related to the servicing of their supply channels; they make extensive use of their own road vehicles. This goes for food, drink, tobacco and furniture too. Other industries, such as Aircraft and Shipbuilding, are abnormal since much of their output transports itself. The same goes for construction industry.

For 59 industries the percentage of own road transport was 30-50 per cent (chemicals, engineering, vehicles, textiles, clothing, paper). For 26 industries, the percentage of own road transport was 10-30 per cent (metal, bricks). For 8 industries, the percentage of own road transport was less than 10 per cent (ores, coal, coke, iron and steel).

It is shown that transport costs are over 15 per cent of the value of net output for industries such as: bread, milk, sugar, animal food, mining, quarrying, coke, fertilisers, bricks, etc.

Whereas transport costs are lower than 2 per cent for industries such as machinery, instruments, radios, telephones, watches, ships, aircraft, locomotives, jewellery, lace, tailored outwear and electricity.

As an average it can be reckoned that transport costs amounted to 10 per cent of the cost of producing and distributing.

As there are considerable practical difficulties in justifying grants to freight forwarders, the alternative of direct grants to industry needs to be considered. But it is necessary to cut down extra transport costs because of fragmentation of the industry, for instance, industries using own trucks with poor utilisation only for advertising reasons.

A preliminary criteria, deficit per transport unit, can only give an unclear picture of the situation.

II. TRANSPORT MODELS

A. ESTIMATION OF TRAFFIC VOLUME BETWEEN CITIES

The amount of travel and hence the optimum transport system (network and service) between city pairs will depend primarily on the size and commercial character of the cities and the distance between them, because of the well-known theory of the inherent relationship between traffic and length of haul. This postulates that the traffic potential between city pairs is related to the product of their populations and a "community of interest" factor, and is inversely proportional to the distance between them.

B. DISTRIBUTION OF TRAFFIC BETWEEN MODES

The distribution of traffic between travel modes in intercity traffic can be calculated by the following formula (16).

$$T_M = k \frac{\text{Frequency}}{\text{Fare . Time}}$$

The trips with a given mode thus are proportional to the service frequency and inversely proportional to the fare and the travel time.

Examples on use of the formula are given on page 131.

Determination of the distances where car, rail or air are faster

Total journey time is a primary factor for the determination of travel mode.

Herrmann from Germany (17) and E.E. Marshall (1) from Great Britain have discussed this problem.

The comparison of block times achieved by different types of transport mode between two cities depend very much on the assumption made for:

- Cruising speed
- Time to reach and leave station and airport including waiting time, etc.

An average travel speed for main railways is often reckoned to 140 km per hour. For future express railroads could be used 200 km/h. For distances between cities of some hundred kilometres the average speed of aircraft will be influenced by the slow speed in the first and the last part of the journey. As an average travel speed may be taken 450 km per hour.

As extra time for reaching and leaving the railway stations and for waiting time Marshall estimates at 50 minutes. Herrmann includes extra time for eventual change of train and comes to an average extra time for train travel of 80 minutes.

As extra time for reaching and leaving the airport, etc., Marshall reckons 135 minutes and Herrmann 165 minutes. If forcoming VTOL aircraft new airports are built closer to the city centre, this extra time may be reduced.

Fig. 2 shows that with an average railway speed of 140 km and Herrmann's extra times the railway is not the fastest at any distance. For a distance between two cities of 300 km all three kinds of transportation actually make the trip in the same time. With an average railway speed of 200 km per hour the railway is being the faster in the interval 200 to 400 km between cities.

If Marshall's extra time for reaching and leaving railway stations, 50 minutes is used, the break even point between car and railway is reduced to about 100 km. If one uses Marshall's 135 minutes for reaching and leaving airport, the break even point between railways with 200 km per hour and air transport is still 400 km. With a speed of only 140 km/h of the railroad the break even point of railway and air transport goes down to about 250 km.

The figures above assume that the traveller is living in the city centre, maybe in a hotel. If the traveller is living in a suburb, Marshall anticipates that the travel time of 135 minutes from home to airport also holds for home to railway station. In this case the railway is not the fastest at any distance. Car will be the faster up till 160 km and for distances of more than 160 km air transport will be the faster.

In this connection it may be referred to the investigation made of the effect of establishing new railway stations in the suburbs of Washington D.C. This would increase the use of railway from 20 per cent to 45 per cent. (Page 122).

C. FORECASTING OF INTERCITY TRAFFIC

A simple formula to forecast intercity traffic was developed by Björkman (16). He maintains that the rate of increase in traffic is proportional to the rate of increase in population, to the rate of increase in purchasing power and to the rate of improvement of traffic service. Using rates of 1 1/4 per cent p.a., 2 per cent p.a. and 2 1/2 per cent p.a. One finds a 10-fold increase of traffic in 30 years. In the following chapters it is anticipated that these rates will be applicable to both Intercontinental, European and Danish traffic and that all three will increase 10-fold from 1970 to the year 2000.

D. NETWORK INDICES AS A MEANS OF EVALUATING DIFFERENT NETWORKS (16)

The network connectivity is complicated and it requires a group of measures to be defined.

A network is a set of nodes (v) (terminals, stops) and links (e). Eventually the network consists of (p) subnetworks, without connection.

A path is a finite set of links. A circuit is a finite path in which the starting node coincides with the last node of the path. A tree is a connected network of at least two nodes such that the network does not contain any circuit.

The "a" index or the circuit index is the ratio between the observed number of circuits and the maximum possible number of circuits. It is calculated as:

$$a = (e-v+p)/(2v-5)$$

if one limits to networks in which only one link can connect the same pair of nodes and to those in which no links can intersect except at nodes. "a" is equal to zero for all trees and disconnected networks. $v > 4$.

The "b" index or the ratio index, is the ratio between the number of links and nodes. "b" is equal to one for a network with only one circuit and bigger than one for a higher number of circuits.

The "c" index or the connectivity index is the ratio between the observed number of links and the maximum number which could exist. "c" is equal to one for a completely connected network:

$$c = e/3(v-2), \quad v > 4$$

These measures are very useful in evaluating various network configurations.

The connectivity index is a measure of the ease of travel between terminals. The greater the connectivity the more direct travel, more places to which one can travel non-stop or without transfer and reduced travel time.

With $v = 10$ nodes and $e = 15$ links one has the following values: $a = 0.4$, $b = 1.5$ and $c = 0.5$, i.e. good connection.

E. DECISION MODELS

Comparison of costs of alternative transport plans can be given in a matrix and decision theory can be used. If one translates planning with a gambling procedure against the nature, can explain the decision model as follows:

As an example the decision concerning establishment of 3 alternative new transport systems, air transport system A, motorway system M and railway system R is to be taken. The forecast of the traffic for a future year is T or 2T or 3T. Let the cost C to use system R with traffic T be C_{R1}.

The cost matrix is the following:

Costs per year	Traffic volumes		in forecast year		Average costs	Maxim. costs
		T	2 T	3 T		
New Transport Systems	R	C_{R_1}	C_{R_2}	C_{R_3}	$\sum \frac{C_R}{3}$	C_{maxR}
	M	C_{M_1}	C_{M_2}	C_{M_3}	$\sum \frac{C_M}{3}$	C_{maxM}
	A	C_{A_1}	C_{A_2}	C_{A_3}	$\sum \frac{C_A}{3}$	C_{maxA}

According to Laplace one should choose the project which gives the minimum of the average costs.

Wald suggests that one should choose the project which minimizes the maximum costs.

Other authors such as Savage and Hurwicz have other suggestions for special situations (which should not be mentioned here).

To calculate costs one should include revenues, construction costs, operating and maintenance costs and social costs such as time savings, accident costs, etc.

The definition of new transport systems should be that, for instance, "railway system" means a system, where the railway system is modified, so that it attracts main traffic, whereas the road- and air systems serve a minor per cent traffic. However, the costs of these systems should be indluded in the railway system costs.

The "motorway system" means a system, where new motorways are constructed, so that the volume of traffic on the other modes is less than before, but their costs are included. The "air transport system" means a system where new air routes are established, but the costs of the other modes are included.

III. INTERCONTINENTAL NETWORK

First the case of the large cities that are a long distance apart - about 10,000 miles is discussed: The Intercontinental network. This network serves the whole world : an area of about 50 million km^2 with about 3,000 million inhabitants. One can define 10 functional regions (nodes): Europe, N.E. America,

E. Asia, S. Asia, Central Asia, Africa, N.W. America, S.E. America, S.W. America and Australia, connected by 15 links (Fig. 3).

A. PASSENGER TRAFFIC

At this distance the passenger traffic is about 30 million journeys per year (0.01 journeys/inhabitant/year and 0.6 journeys km^2/year).

The link with the maximum traffic volume being Europe-N.E. America across the North Atlantic with about 5 million pass/year (1965). The node with the maximum traffic volume being Europe with about 20 million pass/year (1965).

1. Competition sea-air

Since the mid-1950's the growth of long haul passenger travel has been dominated by air transport. While there has been a decline of travel by sea the average growth of long haul, air travel has compounded at 15 per cent per annum. Thus in 1968 air travel accounted for 90 per cent of the total passenger travel across the North Atlantic. This is in accordance with the simple model page 103 describing the distribution of traffic between travel modes as proportional to the service frequency and inversely proportional to the fare and the travel time.

The fares by sea and air are about the same, while both frequency and travel time by boat is 5 days, by aircraft about 7 hours.

These figures can be expected to be the same as the new generation of larger aircraft with improved standards of comfort and lower operating costs are brought into service. The advent of supersonic aircraft, such as Concorde, will approximately halve the journey time for crossing the Atlantic from 8 hours to 4 hours.

Sea passenger traffic has as mentioned only 10 per cent of the traffic, and this is clearly a transport form so unprofitable, that it will be difficult to maintain, even if in the future there will be travellers wanting to combine the crossing of the Atlantic with a leisure time.

2. Charter flights

Improvement in unprofitable scheduled air routes should be aimed at because of competition from charter traffic flights.

However, inclusive tour travel (charter) can exploit the main advantages of air transport in that aircraft are able to take holiday makers to the resorts in only few hours. Thus the main components of the system (aircraft seats and hotel accommodation) are utilized in a more efficient way and average load factors for aircraft and hotel usually exceed 90 per cent. The net result is a quite big total price reduction to the charter customer.

Business travellers will probably use the scheduled routes; holiday travellers will probably use charter routes.

3. North Atlantic traffic in the year 2000

Another question is: can the future traffic volume be handled by air?

From Björkman's model (see page 105) a ten-fold increase in 30 years can be predicted.

About the year 2000 the intercontinental air traffic will then reach about 300 million journeys per year. The link between the two biggest and fast growing urbanized regions: Europe and N.E. America will perhaps reach 50 million journeys per year. This means that a single airway with 12,000 passengers per hour in 10 hours per day in approximately 400 days a year can hardly handle the traffic.

Fortunately several airways and pairs of airports can be used because of the very flexible airway network.

B. FREIGHT TRAFFIC

The intercontinental freight traffic amounts to approximately 1,500 million t. per year (0.5 t. per inhabitant per year, 30 t. per km^2 per year). Most of this traffic is bulk traffic, such as 1,100 million t. fuel, 50 million t. iron ore, 20 million t. corn and 10 million t. sugar. The rest is liner traffic, mainly general cargo.

The link with the maximum traffic volume being Europe-N.E. America with about 200 million t./year (about 5 million t./year liner traffic). The node with the maximum traffic volume being Europe again with 200 million t./year.

With an expected growth of intercontinental freight volume about 8 per cent per year - the same as 1950-1970 - one gets a volume of about 15,000 million t. per year in the beginning of the next century (according to D.O.T. forecasts).

1. General cargo route Liverpool-Calcutta (18)

Saggar investigated conventional cargo liners United Kingdom-India 1970. One of the unprofitable general cargo routes.

Cargo liners are ships plying fixed routes according to a predetermined schedule and offering cargo space at fixed rates. Major proportions of costs are fixed, e.g. ship insurance, maintenance and repairs, crew wages, crew provisions, stores and supplies, administration, port dues and fuel costs. The remainder, the variable costs, are cargo handling costs, cargo insurance, and port dues for berthing periods greater than scheduled time. The round voyage time is taken to be 180 days. This schedule is rarely realised, average round voyage time is 220 days or 110 days per single voyage. This means three single voyages per annum only. If ports of call are reduced from 12 to 4, ships could be used for 8 single voyages. The total cost per freight ton would then fall from £14 to £6.

Mc Kinsey (6) states that using larger ships will only reduce per unit transportation costs as long as port time is low and there is sufficient volume, no competition (these points were not fulfilled for the United Kingdom-India routes).

Increasing ship capacity from 300 to 3,000 containers reduces per unit costs 42 per cent on the North Atlantic route as compared to 55 per cent on the United Kingdom-Australian route i.e. relative reduction in per unit costs are greatest for the longest voyages (Fig. 4).

2. Break-even between feeder and port-of-call services

For a given mileage the cargo volume required to justify a port of call increases with the capacity of the trans-oceanic ship.

A diversion of 500 miles to pick up 300 containers is economic for a 1,000 capacity ship, whereas feeder services are more economic in a similar situation for ships of a capacity of 2,000 containers or above (Fig. 5).

3. Ships versus or combined with rail transport Europe-Far East

The enourmous growth, the containerization and the closing of the Suez Canal collectively provided a new impetus towards "land bridge" operation.

Take a route between the Far East and Europe. A typical time for movement of cargo from Yokohame to Rotterdam via the Panama Canal would be 40 days, handled by Break-bulk ships, 27 days handled by containerships and 23 days handled by containerships on the Pacific and Atlantic routes and unit trains across the United States.

The shortest land route will be the Trans-Siberian Railroad; the question is whether this route will physically be able to handle a sustained movement with its existing operating scheme and capacity.

Schedule reliability during severe winters presents another very real problem.

The ship route via the Panama Canal is 14,000 statutory miles; the United States land-bridge, using San Francisco and New York as an example, is 12,000 statutory miles. Two other routes through Canada or Mexico give only a slight reduction in mileage.

During 1966 3 million t. were exported through Pacific Coast United States ports to the ar East in liner service. It is estimated that 1.5 million t. is containerizable; in the reverse direction, the absolute volume of freight traffic is considerably less, but it is estimated that 1.5 million t. are containerizable. Between New York and Europe a similar pattern develops. To the Orient from Europe moves half a million t. a year. Using a unit train price of 144,000 $ per round trip San Francisco-New York based on an 80-car train capable of handling 320 twenty-foot containers (10 t.) i.e. 3,200 t. per train, would take 160 unit trains just to move this half million tons.

Land miles between the United States East Coast and West Coast are approximately 3,000 miles, whereas sea distances via the Panama Canal is over 6,000 miles. In this situation unit trains are cheaper than container ships of any size (see page 96).

IV. EUROPEAN NETWORK

Consider next, the European network with large cities that are a relatively long distance apart - often more than 500 miles.

This network serves an area of about 5 million km^2 with about 300 million inhabitants. One can define 10 functional regions (nodes): England, France, Spain, Italy, Germany, Austria, Switzerland, Belgium, Holland and Scandinavia with Denmark connected by 15 links (Fig. 6).

A. PASSENGER TRAFFIC

The traffic of this network is about 80 million journeys per year (0.25 jour./inhab./year and 16 jour./km^2/year) distributed on the different modes according to GETA (19) thus:

Road:	40	million pass./year
Air:	15	-
Rail:	15	-
Sea:	10	-
	80	million pass./year

Sea travel comprises trips where other modes also are used in connection with the sea trip such as connections to England and Scandinavia.

The above is only travelling over 500 km and not intercontinental. The links with the maximum traffic volume are London - Paris (air), Frankfurt - Køln (railway) and Frankfurt - Stuttgart (motorway) each with 5 million pass./year. The nodes with the maximum traffic volume being London (airport) and Frankfurt (railway station) with each 8 million pass./year.

1. Number of private and business trips over 200 km per inhabitant per year in the United States and Europe

The GETA (19) study found the number of trips over 200 km per inhabitant per year was in Europe 0.5 (1965) and Lansing (20) found in the United States: 2 (1962).

That means that the Americans travel 4 times more than the Europeans. With increasing wealth in Europe one may expect increasing intercity travel both in business and in private.

The per cent of business trips of all trips in Europe was 38 per cent - in the United States 25 per cent.

The trips were divided between air and surface as indicated in the following table:

Number of trips per inhabitant per year
Distances greater than 200 km

	Europe (1965)		United States (1962)	
	Business	Private	Business	Private
Air	0.028	0.002	0.088	0.060
Surface	0.120	0.400	0.436	1.440
Total	0.148	0.402	0.524	1.500

2. Development of rail passenger traffic with increasing number of automobiles

Fig. 7 shows the development of passenger km per inhabitant per year with increase in motorization in different European countries and in the United States. It is seen that rail passenger traffic in the United States has been decreasing since 1913. Rail has in 1968 only 10 per cent of the intercity traffic with public transport in the United States.

In Sweden there has been a decline in rail passenger traffic since 1950 when the car density was 30 cars per 1,000 inhabitants. In Denmark there also has been a decline, but less pronounced.

The German, English, and Dutch railways had an increase in traffic during the first years of increasing automobile ownership, but from the years where the motorization reached between 40 and 90 cars per 1,000 inhabitants there has been a decline in rail traffic. In France the decline in rail traffic first began at a car density of 200 cars per 1,000 inhabitants.

B. FREIGHT TRANSPORT

The European freight traffic over 500 km amounts to approximately 1,000 million t. per year (3 t. per inhabitant per year, 200 t. per km^2 per year).

Most of this traffic is bulk traffic, such as 200 million t. fuel.

The traffic is distributed thus:

Sea	200 million t./year
Inland waterway	100 -
Rail	300 -
Road	300 -
Pipeline	100 -
Total	1,000 million t./year

The links with the maximum traffic volume are the Channel 100 million t./year and the railway Frankfurt-Ruhr 60 million t./year.

The node with the maximum traffic volume is Rotterdam Port with 100 million t./year (including inland waterways).

Some examples of freight transport mode distribution (21) to Germany from some other countries are given below:

To Germany 1967.

From / By	Netherlands		France		Belgium		Italy	
	mill. t.	p.c.	mill. t.	p.c.	mill. t.	p.c.	mill. t.	p.c.
Watertransport inl.	33	60	9	22	4	50	0	0
Pipeline	14	25	17	45	½	5	6	60
Sea	2	4	1	2	½	5	1	10
Rail	2	4	8	21	1	10	2	20
Road	5	7	4	10	2	30	1	10
	56	100	39	100	8	100	10	100

Air is not included because the percentage is less than one.

As the table shows the percentage share of the different modes of goods transport gives no clear guidelines. Air and sea play a minor part, whereas inland water-transport and pipeline traffic play an important role.

Taking into the picture Japanese and American domestic transport distribution one gets the following distribution 1962 according to <u>t. km</u> in per cent, compared to some European countries.

t. km p.c.	Japan	United States	Germany	Great Britain	Europe
Ship	40 p.c.	20 p.c.	25 p.c.	15 p.c.	30 p.c.
Rail	30 -	40 -	50 -	25 -	30 -
Road	30 -	20 -	20 -	50 -	30 -
Pipeline	0 -	20 -	5 -	5 -	10 -

This table contains all transport over all distances.

1. The development of coal, steel, and oil transport in Europe

The comparative decline of coal and steel transport in these years particularly affected railways in Germany and the United Kingdom. In 1966 coal production in Europe declined 20 million t. Solid fuel traffic by railway was in 1966 60 per cent of all freight t. transport by railways in the United Kingdom, 40 per cent in Netherlands, 30 per cent in Germany and Belgium and 20 per cent in France.

The loss of coal traffic on railways was not fully compensated by other traffic, because oil is more often conveyed by pipelines or road. Petroleum production traffic by road was in 1966 6 per cent of all freight t. transport by road in Germany (solid fuel only 3 per cent), 5 per cent in Netherlands (coal only 3 per cent), 5 per cent in Italy (coal 0 per cent), 4 per cent in France (coal only 3 per cent), etc.

With regard to inland water transport, the growing importance of oil, as compared with coal, had less serious repercussions than on the railways: 20 million t. oil was moved by waterway in Germany in 1961. A rapid development of oil pipeline networks is going on. At a distance of transport of over 100 km and a capacity of about 3 million t. per year the pipeline is the cheapest mean of transport. The main lines in Europe are Wilhelmshafen - Cologne, Rotterdam - Frankfurt, Le Havre - Paris, Marseille - Paris - Karlsruhe - Ingolstadt, Genoa - Ingolstadt, Triest - Ingolstadt, Triest - Wien, Prag - Kiev, etc. (The diameters vary from 24"-34") (22).

2. Location of a pipeline

Ventura (23) investigated the planning of an optimal structure for the French oil refining industry.

Alternatives were evaluated and compared in terms of the total annual cost of making oil products available at consumption points based on forecast consumption levels:

(a) Establishment of new refineries in Strasbourg or Mulhouse or Montereau or Chalon.

(b) Construction of a pipeline Marseille-Paris or Marseille-Chalon or no pipeline constructed.

(c) The price of crude oil.

(d) The level of exports for refined products.

(e) The cost of pipeline transport.

The calculations will not be referred to in detail, however. The result was that besides a new refinery recently established near Lyon there should be established a new refinery in Strasbourg supplied by a crude oil pipeline from Marseille. Besides the refinery in Dunkerque has been extended as suggested in the report.

C. THE SITUATION IN EUROPE COMPARED WITH CORRIDORS, WHICH HAVE SEVERE TRAFFIC PROBLEMS

For the Japanese east coast from Tokyo to Osaka,
the area is 50,000 km^2 and has 50 million inhabitants and 60 per cent of the industry of the whole country.

For the north-east corridor in United States, from Boston to Washington,
the area is 250,000 km^2, the population also 50 million.

For comparison, some (3) European countries data:

West Germany	250,000 km^2 and 60 million inh. / Holland 13 million inh.
France	500,000 km^2 and 50 million inh. / Belgium 10 million inh.

eventually bound together with

England	250,000 million km^2 and 60 million inh. / Denmark 5 million inh.
Italy	250,000 million km^2 and 60 million inh. / Switzerland 6 million inh.

1. The Japanese Shin Kansen network

Japan had in the beginning of the sixties an extensive system of railways loaded to full capacity on the main lines along the east coast.

Some details of this system, in 1963, are mentioned below. The lines are divided in lines running with surplus (3,500 km) and lines running with a deficit (about 17,000 km).

		Lines running with surplus	Lines running with deficit
Length of lines		3,498	17,243
Passenger km	(100 million)	1,048	594
Tonkm	(100 million)	363	226
Income	Billion Yen	344.0	229.0
Expenses	incl. interest and depreciation Billion Yen	264.1	251.8
Surplus or deficit Billion Yen		Surplus 79.9	Deficit 22.8

The lines which give a surplus have a number of passenger km per line km, per year of 33 million and a number of ton km per line km, per year of 13 million.

The lines with a deficit have a traffic which is about one tenth of these figures.

To compare it can be mentioned that the traffic per kilometer of line of the Danish railway lines with the heaviest traffic is just the same as on the lines which in Japan are run at a deficit.

It has to be mentioned that the surplus of 57 Billion Yen in 1963, reflected an increase in salaries which was not followed by a sufficient increase in rates and fares, changed the surplus to a deficit of 30 Billion in 1964. There was also an increase in interest and depreciation.

Because of the heavy traffic it was decided to build a new railway line from Tokyo to Osaka, it was opened in 1964. The maximum speed is 210 km/h. As it parallelled the existing line the new stations could be at about 50 km interval.

The traffic at the Tokaido line was in 1969: 24 million pass./year (150,000 pass./day) with 120 trains per day in each direction. (Peak hour, 1 train every 10 min.). A third Tokaido line will soon be needed to cope with the rising volume of traffic.

In the years 1964 - 1966, the revenue exceeded all costs inclusive of interest on the capital invested.

Concerning the ability of increasing speed of railways to attract traffic from airlines can also be quoted some figures for the years after opening the new Tokaido Line in Japan. The table below shows the traffic between Tokyo and Nagoya in October 1964 and February 1967.

	Oct. 1964	Feb. 1967
New Tokaido Line	300,000	650,000
By air	28,000	1,000

It is seen that the traffic by air between the two cities only 370 km's apart, which was never very great, nearly disappeared after the opening of the new Tokaido Line.

Between the cities Tokyo and Osaka(500 km) the development was somewhat different, but the air travel between the two cities has not increased from 1964 to 1969. It is in 1969 10 per cent of the rail travel; that is much more than the air traffic between Tokyo and Nagoya.

The social benefit for the line was also calculated for the 30 years beginning 1965, the consumers surplus was obtained for each origin-destination (Volume multiplied by time saved per km) to about 14,000 million yen per km, whereas the surplus of the parallel expressway was about 7,000 million yen per km (24) (25). Both results come to 7 per cent of construction cost.

The continuation of the Tokaido line: the new 500 km San-yo line from Osaka via Okayama to Hakata is already completed or under construction. The cost of the extension is £2 million per mile including 50 per cent tunnels, terminals, power supply and rolling stock.

The whole proposed Shin Kansen network consists of 9,000 km new railway. The return on the whole 9,000 km network is only expected to be 3 per cent on capital invested whereas 4,000 km would produce 7 per cent. This means that the "regional development" half will do no more than cover costs of operation. This could impose an unnecessary burden on the profitable lines.

2. The proposals for the North-East corridor in the United States

The passenger traffic on the United States railway lines has been decreasing for many years (see page 113). As there were difficulties with the very heavy road and air traffic along the North East coast-specially the airports in New York were overloaded, the United States Government set up an office of high speed ground transportation in 1965.

The number of passengers per year by rail on the Washington-Boston line is about 1 million. The air traffic is 200 - 300 per cent of the rail traffic.

Several proposals were worked out:

A tunnel between Boston and Washington should be constructed and in the tunnel should run some kind of air cushion trains. Anticipated travelling speed 360 km/h.

New rail line. The travelling speed might be increased to 250 km/h. Cost about £2 million per mile: 2 - 10 car trains on a 5 min. headway in peak periods with a speed of 250 km/h average would take passengers from New York to Washington in 1½ hours. An increase in passengers to 5 million per year was expected.

Introduction of Metroliners. Cost 60 pC of new rail line. Started 1969. Average speed is 130 km/h, traffic increased from 1 to 2 million and load factor from 50 to 70.

(a) Calculation of the relative economy of railway, bus and VTOL aircraft in areas with different population density

Morlok (26) has compared three technology classes that are available for intercity transportation of persons:

High speed railroad, bus system operating on freeways and VTOL vertical landing and take-off aircraft system.

The investigation was made in connection with the N.E. corridor study.

The variables used are: node density, connectivity and travel time, frequency, capacity, transfers, intermediate stops, rest and eating availability and space per seat.

Morlok has related the "terminal density" to the "fixed network connectivity" for the three modes railway, bus, VTOL aircraft. Terminal density is taken as a measure of the difficulty of gaining access to the intercity system. Connectivity is a measure of the ease of travel between terminals (see page 106).

The greater the connectivity the more direct travel, more places to which one can travel non-stop or without transfer, reduced travel time.

In the following only the result is given.

Link length was set at 40 miles and each interchange (node) serves 1,400 sq. miles, however, the lowest inter-terminal spacing was about 5 miles.

The level of frequency was a base headway of one hour (24 departures per day) with four-car trains corresponding to 600 seats per hour per link in each direction, and 60 per cent load factor was assumed.

To obtain the same amount of travel it was necessary to operate 180 bus departures per day and 90 aircraft departures per day per service to produce a flow equal to that of the trains.

The total annual cost per unit area ($ per sq. mile) shows that bus is cheaper than either rail or VTOL, at any particular level of connectivity and terminal density even at the relatively high capacity 600 pass./hour.

At a connectivity of 0.5, bus costs per unit area are only one quarter to those of VTOL (30,000 $ per sq. mile per year) and only one half to those of rail (15,000 $ per sq. mile per year) at low terminal density. However, the bus services are not equivalent to the rail and VTOL systems concerning speed, size of seat, eating service, etc. The fact is that bus and rail costs are essentially determined by the connectivity and relatively independent of terminal density; this is not the case with VTOL: here a connectivity increase from 0.4 to 0.7 will halve terminal density for a cost of 30,000 $. VTOL is not always better suited to highly connected networks than high-speed railway. At values of connectivity less than 0.5 and terminal density greater than that of 700 sq. miles hinterland rail has lower cost than VTOL.

Morlok also gives connection between frequency and non stop travel at equal cost levels for rail, bus, and VTOL (<u>Fig. 8</u>).

For an annual cost of each mode per terminal of 4 million $ (only cost of service, not fixed costs) one finds that the number of terminals reached without vehicle transfer for a fixed departure frequency 24 per day is for railway 2½ stations, for VTOL 10 stations, for bus 30 stations.

This ordering of, bus better than VTOL, better than rail is precisely inverse of that for speed, where VTOL is best, then rail and buses the slowest.

If one is interested in frequency and destinations reachable without transfer and not in capacity, one can compare costs at a service level like the one mentioned for railways (24 departures per day, 2½ stations reached without transfer) with costs of 4 million $ per terminal/year then bus costs will be 0.4 million $ per terminal/year and VTOL costs 1.5 million $. However, there are substantial differences in capacity.

(b) <u>Trip division between modes: Philadelphia - Washington (200 km)</u>

Beimborn (27) has worked with choice of modes of travel between Philadelphia and Washington taking into consideration the income level of the travellers divided in 3 groups: less than 3,000 $, 3 - 10,000 $ and more than 10,000 $, corresponding to the value of one hour of 1, 2 and 5 $.

8 modes are connecting Philadelphia and Washington:

3 air modes, using Dulles, National and Baltimore.
2 rail modes using Philadelphia 30th str. or North.
2 bus modes, using Washington CBD or Silverspring St.
1 car mode.

A travel intensity of each income group was used:

For less than: 3,000 $: 0.77
3 - 10,000 $: 0.90
more than: 10,000 $: 1.35

if the average number of trips is 1.

The distribution of the trips on the various modes was:

	Less than 3,000 $ a year	3,000 to 10,000 $ a year	More than 10,000 $ a year
Rail	5 per cent	25 per cent	20 per cent
Road (Bus	70 - -	15 - -	
Road (Auto	25 - -	60 - -	45 - -
Air	-	-	35 - -

An impedance function was used to compute mode distribution, and a gravity model was used for each income group. As the level of auto availability increases, it would have the most effect on bus travel. Airlines would be least affected.

It was also investigated how a change in travel time, etc., would influence the distribution on modes.

Travel time by rail Washington-Philadelphia	Increase in passengers by lower travel time
133 min. (existing)	0 per cent
100 -	20-24 per cent(*)
80 -	30 per cent
40 -	40 - -

(*) 1 $ fare increase.

Most effect is for medium and high income.

An example of the effect of improvement in bus services: Existing travel time 240 min. and one bus every 2 hours; 175 min. and one bus every hour would increase the use of Silverspring station from 1 per cent to 21 per cent.

Improvement of access to Dulles airport would have littre effect.

New railway stations at the Beltway in Maryland and in Virginia mean an increase in rail travel from 20 per cent not to 45 per cent, or more than increase in travel time by rail.

The Kraft model (28) includes attractiveness and trip purpose, and gave the following results for private trips and business trips.

The tables below give per cent change in traffic volume for 1 per cent increase in value of the indicated variable. (The exponents of the variables are their elasticities).

Private trips

	Population product	Income	Attractiveness	Cost				Time			
				Rail	Bus	Air	Auto	Rail	Bus	Air	Auto
Rail	0.9	0.5	1.6	-3.0	3.1	0	0	-2.6	0	0.1	0.1
Bus	0.7	2.5	1.9	0	-0.7	-	0	0	-1.6	-	0
Air	0.9	1.9	1.0	0	-	-0.9	0.1	0.9	-	-2.2	1.1
Auto	0.8	1.5	1.6	0.2	0	0.5	-0.9	0.5	0.1	0	-1.4

It is seen that if the travel time by rail is increased by 1 per cent the number of trips by air will increase by 0.9 per cent.

For Business trips the figures are the following:

	Employment product	Income	Attractiveness	Cost				Time			
				Rail	Bus	Air	Auto	Rail	Bus	Air	Auto
Rail	0.9	-	-	-0.4	2.3	0	0	-4.4	0	0.4	0
Bus	0.8	-	-	0	-0.7	-	0	0	-1.7	-	0
Air	0.9	1.4	0.8	0	-	-0.9	0	1.0	-	-2.1	1.0
Auto	1.1	-	0.3	1.1	0	0	-0.4	0.8	0	0	-3.4

D. RESHAPING BRITISH RAILWAYS

Beeching (29) reshaping of the British railways has been one of the biggest operations in Europe to evaluate unremunerative public transport services.

The working deficit of British Railways in 1962 was: £100 million.

The following measures were carried through:

(a) During the period 1962-68 the number of staff employed was reduced from 500,000 in 1962 to 300,000 in 1968.

(b) Closure of unremunerative lines and stations. The number of route miles was reduced from 17,000 in 1962 to 13,000 in 1968, the number of stations reduced from 5,000 in 1962 to 2,700 in 1968. (30 per cent of the route miles had 1 per cent of traffic and the receipts were 10 per cent of the expenses). (50 per cent of the stations had 2 per cent of the traffic).

(c) The rolling stock was reduced thus:

From 14,000 locos in 1962 to 5,000 in 1968 (incl. new diesel and elec. locos) from 36,000 cars in 1962 to 20,000 in 1968 (incl. new passenger carriages) from 900,000 wagons in 1962 to 450,000 in 1968 (incl. new freight-container wagons).

(d) Reduction in train miles from 335 million in 1962 to 250 million in 1968.

All this has, however, not been able to eliminate the deficit. It may be attributed to the following factors:

(i) Labour earnings increased faster than labour productivity.

(ii) Railway receipts per passenger/net ton mile increased only by 4 per cent while working expenses rose by 22 per cent.

(iii) It may be noted that subventions to bus services substituted for unremunerative passenger trains cost £½ million in 1966.

(iv) Available resources were used for modernizing and developing main routes.

(v) Investment in signalling automation and electrification. £100 million were used.

(vi) £100 million were spent for London-Manchester/Liverpool electrification during 10 years.

Evans (University of Sussex) (30) analysed the benefits from the improvements of London-Manchester/Liverpool electrifications. (200 miles). He found that 25 per cent reduction in travel time gave an increase in passenger traffic of about 40 per cent.

The reduction in travel time gives a yearly social benefit of £2 million. The increase in traffic gave a yearly receipt of another £2 million.

Money saved by use of rail instead of air gave a yearly benefit of £0.25 million.

The passengers having transferred from air to rail in the English case saved per year £0.25 million. The people who used the railway both before and after the electrification gained £2 million per year in saved time.

The difficulties of British railways can also be attributed to the fact that the United Kingdom is ahead of other major European countries from the viewpoint of domestic air traffic. 5 million passengers in 1967, average trip length 350 km. London - Glasgow/Edinburgh 1 million passengers in 1967, average trip length 550 km. Another railway competitor is the charter potential.

Trip division by modes in the United Kingdom

In the Southampton study (31) a division by modes for business trips was found for the United Kingdom. The investigation comprised 14,000 trips.

Similar investigations are in 1970-1971 made in other European countries. The study for Denmark is made by the Technical University in Copenhagen, but no results are yet available.

In the United Kingdom the following distribution by modes were found for business trips in relation to trip length:

	<100 km	100-500 km	>500 km	Total
Rail	10 p.c.	50 p.c.	20 p.c.	30 p.c.
Road	90 -	25 -	5 -	60 -
Air	0 -	25 -	75 -	10 -
Total	50 -	45 -	5 -	100 -

By comparing with the results for the trips Washington - Philadelphia, page 122, it is seen that for trips 100 - 500 km rail is used more and auto less than in the United States.

The mode in relation to duration of journey was also investigated:

	0 nights	1 night	Over and 2 nights	Total
Rail	14 p.c.	7 p.c.	9 p.c.	30 p.c.
Road	40 -	7 -	13 -	60 -
Air	4 -	3 -	3 -	10 -

Car is used especially for one day trips.

It was also asked why the business-men choosed the various modes:

	Min. Journ. time	Convenience of "termini"	Reliability or Economy
Rail	50 p.c.	20 p.c.	30 p.c.
Road	40 -	40 -	20 -
Air	80 -	10 -	10 -

Minimum journey time is a very important point for all modes.

For the business-men travelling from London was asked the means of transportation to the terminal.

	Rail	Taxi	Cardriver	Carpass.	Bus	Walk	
Rail	40 p.c.	20 p.c.	15 p.c.	10 p.c.	10 p.c.	5 p.c.	100 p.c.
Air	10 -	10 -	50 -	20 -	10 p.c.	0 -	100 p.c.

Car traffic dominates the access to airports.

E. THE PLANS FOR A NEW EUROPEAN 200 - 300 km/h RAIL SYSTEM

To-day the TEE network (1. class) has only 2½ million pass./year, 10 per cent travelling less than 200 km, 20 per cent more than 500 km, 70 per cent between 200 and 500 km.

It seems then that the TEE trains have not been able to compete effectively with the air traffic. The speed is not high enough.

A plan for a new high-speed network has been set up as shown on fig. 9 . It is not anticipated to build a complete new system. The old railway lines can be used when the radii of the curve is sufficient for the high speed, but in many sections complete new lines must be built. According to fig. 2 , page 104, it seems essential that the average speed of the trains is more than 200 km/h if they shall be able to compete with air transport.

There seems no insuperable technical difficulties in using maximum speeds of 300 km/h.

The French railways are already rebuilding part of their lines from Paris to Bordeaux, Marseille, Lille, and Strasbourg to 200 km/h. The Italians plan a new line Florence-Naples with the same maximum speed. In Germany a new or rebuilt line Hamburg-Munich via Cologne and Frankfurt is proposed. On the Munich-Augsburg line 200 km/h trains were introduced some years ago.

In France the criterion for rebuilding lines to 200 km/h is at least 5,000 pass./day (2 million pass./year).

It should be noted that unlike Japan the European railways are not faced with a capacity problem.

The anticipated travel times Paris-London 3 hours with channel tunnel, Paris-Lyon 2 hours (6 - 8 million pass./year) are such that real competition with air traffic should be possible.

The future system should appear as an European super network. No frontiers, a single railway agency with European fares, an assimilation of railway techniques and operating methods and improved service are necessary.

In these years much research is being done in trying to develop new kinds of intercity transport modes, such as air cushion trains or some kind of vacuum trains in tubes or monorails. These types of new modes shall, however, not be mentioned here.

F. TRAFFIC POLICY IN VARIOUS COUNTRIES

In the various countries there is a general interest in achieving an optimal distribution of transport that gives an effective service and revenues which cover the expenses.

A question which is discussed in all countries is how to cover the infrastructure costs. The railways infrastructure costs are usually included in the railways account. However, much discussion is devoted to how much trucks and cars shall be charged for their infrastructure costs (see also page 96).

The following table (32) gives information on some European countries about railway and road transport of freight. It is seen that there in some countries is a restriction on free operation, but this is not the case in Sweden and England. In most countries road hauliers have to have a permission to operate. The taxation of trucks is also different from country to country. In all countries there is a fixed weight tax on trucks, but in Norway besides there is a charge per km and in Germany there is a charge on ton km.

	Denmark	Sweden	Norway	West Germany	England
<u>Railway</u>					
Transport obligation	Y	N	Y	Y	N
<u>Road</u>					
Road haulage legislation	P	D	D	K	P
Weight tax per annum					
20 t. truck	1,600 $	5,600 $	4,500 $	6,500 $	No information
Axle load	8 t.	10 t.	2.5 t. (8 t.)	10 t.	10 t.

Y yes D Demand investigated P Permission

N no K Quota system

The permitted axle load is also different. In many countries it is 10 tons, but in Denmark and Norway it is only up to 8 tons.

For the railways traffic in complete train loads effected between specific freight nodes and according to timings fixed in advance, present economic advantages. By avoiding marshalling yards,costs are reduced and maximum use is made of train capacity.

In Germany there has been an increase in deficit of the D.B. (German Federal Railways) up to 1,600 million DM in 1967. In the same year 17,000 were killed on the roads. In 1967 the Minister of Transport, Mr. Leber, presented a plan to improve the situation which essentially endeavours to transfer long distance bulk road traffic to the railways (33).

In the transport plan for Great Britain in 1967 is the objective:'To make the maximum economic use of our railways as well as our roads by promoting the transfer of all suitable traffic from congested road to the railways.' A proposal was made for a new road haulage licencing and a new National Freight Corporation (34).

A special calculation, based on replacement costs, made by British Railways in 1966 showed a deficit of £160 million. £85 million occurred from freight transport and of this £36 million was on goods conveyed in 'wagon loads'.

On French railways 900 km tracks only used for freight transport were closed down in the period 1958 to 1968, but in the same period several new sidings for industry were constructed.

In the Netherlands the traffic in waggon loads has declined. In 1970 the deficit of the Netherland railways was 400 million florins. A great deal of that comes from freight traffic (35).

The introduction of container trains over long distances such as from Switzerland to Denmark with no shunting of the train during the transfer between these countries is an advantageous mode of freight transport by rail.

The balance of the Danish state railways is mentioned on page 133.

V. DANISH NETWORK

Consider the Danish network with "big" cities 150 km apart. This network serves an area of 50,000 km^2 with 5 million inhabitants. One can define 10 functional regions (nodes) : Copenhagen, Aarhus, Odense, Aalborg, Esbjerg, Herning, Kolding, Aabenrea, Slagelse and Nykøbing F. connected by 15 links (16) (Fig. 10).

This whole area is not greater than the Los Angeles Regional Planning Area.

As Denmark is an archipelago, its communications are a combination of land, ferry and air traffic. East and West-Denmark are separated by the Great Belt. The principal components of the land networks (road and rail) are the connections E-W: Copenhagen-Esbjerg, and N-S Aalborg-Aabenraa in East Jutland.

The principal inland air routes are radial lines from Copenhagen to 7 cities in West Denmark.

The principal inland sea passenger routes from Copenhagen to Aarhus and Ålborg have just been closed down.

If one uses the network theory mentioned page 105, the Danish land network has:

circuit index:	a = zero
ratio index:	b = 0.8
connectivity index:	c = 0.33

which is poorer than the network indices in other European countries of the same size as Denmark, for instance, the Netherlands, Belgium, and Switzerland.

With 10 nodes and 15 links these networks would have the following values: a = 0.4, b = 1.5, and c = 0.53 which is the normal values for European countries.

An increase of the number of links in Denmark from 9 to 15 in land transport means a lot of bridge and tunnel construction.

A. PASSENGER TRAFFIC

Passenger traffic on distances above 100 km and not outside Denmark is 100 million journeys year 1966 divided as follows, with the road dominating the market:

Road	86	million	journeys/year	
Rail	12	-	-	-
Air	2	-	-	-
	100 million			

20 journeys/inhabitant/year and 2,000 journeys/km^2/year.

The nodes with maximum traffic volume being Copenhagen airport with 6 million and Copenhagen railway station with 4 million passengers/year.

The number of travellers per day Copenhagen-Aålborg was in 1970 about 4,000 passengers/day.

The distribution of this traffic was, when the ship connection was still existing (see next page 131), as indicated in a table below.

The distribution after the closure of the ship connection is not known, but can be calculated by the formula page 103, when travel time, service frequency and fares for the different modes are known. These are indicated in the table below.

It is shown how the distribution after building on a Great Belt bridge will be.

It is to be observed that with the existing network there is a detour factor for landtransport of 2, compared to sea and air.

The distance between Copenhagen and Aalborg is 250 km as the crow flies.

Travel time, service frequency and fares Copenhagen-Alborg

	Travel time		Service frequency departures per day		Fares
	1970	With Great Belt bridge	1970	With Great Belt bridge	1970
Rail	360 min.	200 min.	7	21	90 kr. (2 class)
Road	360-460(*)	200 -	50(**)	-	230 kr.(***)
Air	120 min.	120 -	7	21	160 -

(*) According to what ferry connection is used.

(**) Ferry connections.

(***) 1 person in the car. 60 öre per km.

Distribution on modes of traffic Copenhagen-Ålborg

	1960	According to formula page 103.	
		without ship connection 1970	With Great Belt bridge
Sea	50 p.c.	0 p.c.	0 p.c.
Rail	10 -	20 -	33 -
Road	30 -	45 -	33 -
Air	10 -	35	33 -

Bjørkman's formula, page 105 claims that the traffic in the year 2000 should be 10 times as big as in 1970, this means 40,000 passengers/day or 15 million per year. With Great Belt bridge built this means 5 million passengers per year on each mode.

B. FREIGHT TRAFFIC

The freight traffic in Denmark, transported more than 100 km, is about 30 million t. per year divided as follows with the road dominating the market:

Road	20 million t/year
Rail	4 -
Sea	4 -
Pipeline	2 -
	30 million t/year

That is 6 t. per inhabitant per year or 600 t. per km^2 per year.

The node with the maximum traffic volume is Copenhagen harbour with 8 million t. and Copenhagen railway station with 2 million t. freight per year.

As an example is taken the Copenhagen-Ålborg freight traffic 1966:

	Service time	Charge per t.	Frequencies	Volume
Sea	20 hours	40 d.kr.	1 dep./day	2,000 t./year
Rail	17 -	45 -	1 -	400 -
Road	24 -	61 -	1 -	200 -
Air	5 -	1,200 -	7 -	

It is seen that the distribution on modes is quite different from the average for the country. In the Copenhagen-Ålborg traffic sea transport is dominating.

The table also gives service time, charge per t., frequencies and Traffic volume for the different modes.

C. PROPOSALS FOR MODIFICATION OF THE DANISH RAILWAYS

The Danish rail system consists of the Danish State railways (1971: 2,352 km) and some Private Railways (1971: 535 km) owned by municipalities.

The Danish State railways, as many other railways, run with a deficit. In 1969-70 the deficit was 328 million kroner. This is calculated thus: (37).

	1969-70
Running expenses	1,150 million kr.
Income	1,037 - -
Deficit of the service	113 - -
Interest and depreciation	215 - -
Total:	328 million kr.

The rate of interest has been unchanged for years and is 4½ p.c. p.a. The result is 70 million kr. better than 1968-69 partly because the number of staff decreased with 750.

1. Comparison with The Netherlands and Sweden

The population density in the Netherlands is about 3 times as high as in Denmark (Fig. 11).

It is seen that the distance from Maastricht to Groningen is about the same as from Aalborg to Padborg, but it is not quite as far from Enshede to the Hague as from Copenhagen to Esbjerg. The Netherlands railways (N.S.) shown on the map are all electrified. The Danish state railways have diesel traction.

After electrification and other modernization the passenger traffic on N.S. grew from 158 million trips in 1950 to 196 million trips in 1960 or with 24 per cent. See Danish figures page 141.

In 1970 a new Spoorslag 70 programme was introduced creating a timetable offering higher speed over longer distances and good frequencies over shorter distances.

In the Netherlands express trains are now connecting 40 stations with a maximum speed of 140 km per hour. There is from 1 to 4 trains every hour from all stations.

This has turned a declining trend of passengers to an increase of 7-8 per cent in 1970 (5).

In Denmark the train density is not nearly as high as in the Netherlands. The traffic volume in Denmark is not great enough for 1 train per hour.

In the Netherlands a coordination of the railways and the regional bus service is envisaged.

The Danish State railways have a project now to concentrate the dispatch of parcels on maybe 20 stations. A system similar to the Van Loos transport system which is used on the Netherlands railways when parcels are accepted by the railways at 9 stations.

It is not known, how the passenger kilometres in Denmark are divided on trips of different lengths. For the Swedish railways (37) where the decline, however, was bigger than in Denmark, see fig 12, this is known.

The number of trips less 100 kilometres has been decreasing in the whole period. The number of trips between 100 and 300 kilometres has been about constant. The number of trips over 300 kilometres has been declining from 1965 probably because of the competition from the now more developed domestic air service.

2. Closure of seoondary stations in Denmark

In 1954 a thesis (38) at the Technical University, investigated how much the Danish State railways would save per year, if 253 secondary stations were closed down. The result was the following :

Savings by closing down 253 secondary stations:

Station service	16 million kr. per year
Trains	5 - - - -
Traction	23 - - - -
Other expenses	2 - - - -
Total	46 million kr. per year

It was anticipated that the railways would introduce a bus service. The running expense for the bus service was calculated to be:

	18 million kr. per year
Yearly saving	28 million kr. in 1954

The investigation was based on a sample where a line of 90 km length was studied in detail.

The running expenses that year of the Danish State railways were 470 million kr. and the closure of the secondary stations would then only mean a decrease of the expenses of 10 per cent. The deficit of the Danish State railways this year including interest and depreciation was 40 million kr.

In 1940 the number of stations was 520. In 1969 it was reduced to 400 of which 98 are with no employees.

3. Closure of branch lines

During the years many branch railway lines have been closed down in Denmark (fig. 13).

The Danish National Planning Board (9) found it desirable that a survey of the future railway network should be prepared and, in 1968, a report was published dividing the railway lines into 5 groups: mostly according to the traffic in 1964-65, but other viewpoints were also taken into consideration.

(i) Railway lines to be maintained

In this group came lines with more than 24 million passenger km and more than 25 million ton km to and from the line per year. 3 more lines with less traffic, but deemed of importance partly because of heavy excursion traffic were included in this group.

(ii) Railway lines to be maintained until further notice

In this group came lines with more than 12 million passenger km and more than 12 million ton km to and from the line per year, and not in group (i). 5 more lines with less traffic, but otherwise being of importance, were included in this group.

(iii) Railway lines where further investigations should be made

In this group came lines with more than 3 million passenger km and more than 1 million ton km to and from the line per year and not in groups (i) or (ii). 4 lines with less traffic were included in this group.

(iv) Railway lines where only freight traffic should be maintained

In this group came lines with very small passenger traffic and more than 3 million ton km to and from the line per year. 3 lines with less traffic were also in this group.

(v) Railway lines to close

Lines with less traffic than indicated above.

	To close				Converting to freight lines		
	Length of line	Yearly savings	Loss of income per year	Profit per year	Yearly savings	Loss of income per year	Profit per year
Lines to be closed		mill. kr.	mill. kr.	mill. kr.	mill. kr.	mill. kr.	mill. kr.
1. Slagelse-Naestved	40 km	2.2	1.0	1.2	1.7	0.7	1.0
2. Viborg-Herning	48 -	1.9	0.5	1.4	1.6	0.5	1.1
3. Laurbjerg-Silkeborg	37 -	1.6	0.2	1.3	1.3	0.2	1.1
4. Funder-Brande	37 -	1.5	0.2	1.3	1.1	0.2	0.9
5. Brande-Grindsted	28 -	1.5	0.2	1.3	1.7	0.1	1.0
			Total:	6.5			
To be converted to freight lines							
6. Slagelse-Varslev	34 km	1.2	0.7	0.5	0.9	0.2	0.7
7. Randers-Ryomgård	36 -	2.0	0.8	1.2	1.6	0.4	1.2
8. Grindsted-Bramminge	40 -	2.3	2.1	0.2	1.5	0.4	1.1
9. Skive-Nykøbing M.	30 -	4.4	2.5	1.9	2.7	0.8	1.9
10. Tønder-Tinglev	27 -	1.2	0.4	0.8	1.0	0.3	0.7(*)
11. Rødekro-Åbenrå	7 -	0.8	0.5	0.3	0.4	0	0.4
						Total:	6.6

(*) New industry is expected to develop along the line.

The Danish State railways wanted a more detailed investigation of the economy of some of the lines with light traffic. A committee of the State railways (39) investigated: (in 1969) 11 branch lines with the result: 5 lines were recommended for close down and 6 for conversion to freight lines. Two other lines investigated should continue.

For the lines 2, 6 and 11 it is expected that the railways will establish a new parallel busline. For these lines no loss of income for passenger traffic is expected and from the yearly savings is deducted the expenses for running the bus lines. For the lines with no substitute bus lines, all internal passenger income is expected to be lost. 20 per cent of the income for travel from the line to stations beyond the line is also lost.

For the lines closed down a drop of income is expected from waggon loads of goods of 33 per cent. The total savings by closing down and altering the mentioned 13 Danish railroads would be 13 million kroner a year, which is only about 4 per cent of the total deficit in 1968 of 328 million kroner.

Social costs, such as loss or gain in travel time after closing of a line, were not considered in this calculation, nor were such facts that the existence of a railway may keep down the rates of private truck carriers in the area around the railway.

The Swedish State railways also have made investigations of unprofitable branch lines. The limit of unprofitable lines was suggested as lines with less than 1 million gross ton/km per km per year. These lines comprise 54 per cent of the total rail system but had only 6 per cent of the total gross ton kilometres. Some of these lines were deemed necessary for the community. To keep up these lines the Swedish State railways got in 1966 a grant of 100 million Kroner a year.

(a) A German method to decide which local railways should be closed (40).

A comparison is mentioned below on a German investigation of unprofitable lines (see page 138).

In 1958 an investigation was made by Pottgieser concerning the question, which of 32 local railways in the Hamburg district should be closed down.

For each line it was calculated both local income = L for transport only on the line investigated and all income = A

LINE NUMBER:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Less than 20 km long								X					X			X			X	X						X	X			X	X	X
All income less than expences																										X					X	X
$\frac{\text{local income}}{\text{expences}} \cdot 100$, greater than 200										X					X	X		X	X		X	X	X	X	X	X	X		X	X		X
$\frac{\text{All income}}{\text{Local income}}$ less than 2						X	X		X					X																	X	X
Outside traffic balance negative														X							X	X	X	X	X	X	X	X	X		X	X
Transported persons per km less than 100.000											X	X	X					X	X	X				X	X	X		X	X	X		X
Dispatched/t per km less than 1000																	X				X						X	X	X	X	X	X
Income per km less than 10.000 DM.																				X		X	X	X	X			X	X	X	X	X
Net tonkm/km less than 30.000															X		X										X	X	X	X	X	X
Total of negative factors for each line	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4	4	5	5	5	6	6	7	9

including all income from traffic originating on the line including income from the movement of this traffic on other lines.

Also expenses, length of line, transported persons per km, dispatched t. per km, and net tonkm/km, were calculated and used to determine those 9 factors shown in table.

"Outside traffic balance" = 0, should take into account that the fixed expenses in the adjoining lines will rise in all cases. 0 is defined thus:

$$0 = A + L) \cdot 0.46 + L + E$$

where E is the expenses.

The average number of trips on DB was 1.2 million passenger km/year. The limit in the table is taken as 100,000 km.

The average Tkm per km/line is for DB 10,000 t. As the limit in the table 1,000 is taken.

The average net ton km per km is for DB 2 million, and as a limit in table 30,000 is taken.

The average income per km of line was for DB 200,000 DM. As a limit in table 10,000 is taken.

From table it can be found that 9 lines have more than 4 "negative factors" and they are suggested for closing down.

No social costs were taken into account.

(b) An English attempt to include social costs in evaluation of branch lines

Else and Howe (46) have investigated the effect of withdrawal of local rail passenger service between Sheffield and Barnsley. They make assumptions of how the former railway passengers will be distributed. One assumption is:

Diverted to bus	58 per cent
- - private car	22 - -
Trips no longer made	20 - -

The most important social cost appears to be the cost arising from longer time spent on the bus journey than on the former railway journey. The extra time was calculated from time tables for rail and bus, and the value of 1 hour was determined in a similar way as indicated page 98. The total amount was £29,000 a year.

For people using private car the travel time was expected to be about the same as with rail.

It was expected that the extra buses and private cars would decrease the speed on the streets used. This would delay other traffic. This delay was calculated as a value of £1,000 a year.

For the journeys no longer made it was calculated that a loss equal to half the value of additional journey time for bus instead of rail would be occurred. This amounted to £6,000 a year.

4. Modification of main lines

(a) Electrification (41)

A committee set up by the Danish Academy of Sciences investigated in 1954 the traction problem of the Danish State railways. At that time mostly steam traction was used.

The price of electricity for traction was in Denmark at that time 5.5 øre per kilowatt and the price of diesel oil was about 21 øre per litre. The reason for the cheap diesel oil in Denmark is that there is no taxation on diesel oil. This is quite different in the Federal Republic of Germany, where there is a tax on diesel oil.

The traffic on the mainlines of the Danish railways amounted to 4 to 13 million gross t. kilometres per km line.

The above calculation was based on the same speed and the same amount of traffic as existed in the year of investigation.

It is seen from fig. 14 that diesel traction in that case is cheaper.

There was also made a calculation for 25 per cent increase in speed and in traffic, and in this case the expense of diesel and electric traction would be about the same.

The railways decided for diesel traction on all lines with the exception of the electrified suburban lines by Copenhagen.

The old steam locomotives for express trains had an effect of 1,100 to 1,300 HP and the diesel locomotives bought in the first years after 1956 developed 1,500 HP, later increased to 1,950 HP and 3,300 HP.

The average speed of locomotive trains without stop Copenhagen-Korsør (110 km) increased from 75 km/h in 1955 to 90 km/h in 1970 or with 20 per cent.

The Danish State railways also run multiple unit trains. An older type with maximum speed 120 km/h made the run in 1955 with an average speed of 97 km/h. A new type with maximum speed 140 km/h in 1970 has an average speed of 108 km/h or an increase of 12 per cent.

The passenger traffic on the Danish State railways increased after a low in 1956 of 2,400 million passenger km to 2,730 in 1966-67 or 14 per cent. In 1969-70 it dropped to 2,550.

The electrification of the London-Manchester-Liverpool line gave an increase in travel time of 25 per cent and an increase in passengers of 40 per cent (see page 124).

The freight traffic on the Danish State railways increased from 1,200 million t. km in 1948 to 1,600 million t. km in 1962, but then decreased to 1,400 million t. km in 1967.

(b) Single track or double track

With the new means of electronic signalling the capacity of single track lines can be increased over the former estimated capacity of 40-50 trains per day (page 92).

The Danish State railways had anticipated building two tracks on their line along the east coast of Jutland from Lunderskov to the frontier at Padborg. On account of the new type of signalling and maybe also because the traffic development was not so great as formerly expected, it seems that single track will be enough. The new line to the continent from Vordingborg to Rodby is also built as a single track line. The capacity is mentioned page 92.

In the United States and in France several lines with double track have been rebuilt to single track.

5. Will the long distance passenger traffic in Denmark in the future be served both by railways and domestic airlines?

From 1866 one had an extended system of ship connections from Copenhagen to the provincial towns in Jutland. The routes to the smaller towns were closed down in the 1950s, at least for passenger traffic. The lines to the two big towns Aarhus and

Aalborg were closed down in the fall of 1970 because of decline in the number of passengers. New ships had been put in, but even the very convenient new ships could not turn the decrease in passengers to an increase.

It should be mentioned that there is an interest in opening, instead long distance bus lines from Copenhagen to the said two cities in competition with air and rail transport. (See Holroyd (42).)

Information concerning the size of the traffic on the main railway lines in comparison with the traffic on the main roads is given in Fig. 15. This shows the result of an investigation on the traffic in 1963 (43).

It should be added that the traffic on the railway lines is about the same in 1970 as in 1963, whereas the traffic on the roads has increased nearly 50 per cent from 1963 to 1970.

As example is the traffic from Roskilde to Korsør, being the main connection from east Denmark to Jutland. The following table gives the road traffic per day. The trucks are multiplied by 2 to make it possible to add the trucks to the passenger cars. The table also shows the rail traffic. On the average it can be seen that the whole passenger traffic by rail could be carried in 500 buses a day, equivalent to 1,000 passenger cars. The rail freight traffic would need 5,500 trucks a day equivalent to 11,000 passenger cars. It is clear that the rail freight traffic would take up much more space on the roads than the passenger traffic.

The traffic Roskilde-Korsør by Road and Rail all expressed in passenger cars.

Traffic 1963	Necessary number of buses and trucks	Equivalent number of passenger cars
Rail passenger-traffic if served by buses	500 buses/day	1,000 passenger cars/day
Rail freight-traffic if served by trucks	5,500 trucks/day	11,000 -
	Total:	12,000 -
Road traffic		10,000 -
	Total:	22,000 -

The existing road Roskilde-Korsør is mostly a 3-lane road with a capacity of maybe 12,000 cars per hour. It will be seen that it is impossible also to have the rail-freight traffic on the road. A 4-lane motorway is under construction and the capacity of this 4-lane motorway can be reckoned to 35,000 passenger cars per day. Even this raod could hardly also take the rail traffic. It all the rail-freight traffic should be on the road it will have to be constructed as a 6-lane motorway instead of a 4-lane motorway.

Concerning the other possibility of transferring all the rail passenger traffic to domestic airlines it should be mentioned that rail passenger traffic from East Denmark to West Denmark across the Great Belt is only about 3½ million passengers a year. That is not much in comparison with the traffic on Copenhagen airport which now is close to 7 million passengers a year. Actually there is a forecast that Copenhagen airport in the year 2000 will have 30 million passengers. 3½ million rail passengers, therefore, is only a small part of the forecast for the future traffic from Copenhagen airport, which eventually will be transferred to the island of Saltholm in Øresund. For capacity reasons there seems on an average day no difficulty in transferring all the rail passenger traffic to the domestic airlines in the future. Another question is the maximum traffic on Easterday evening (see page 147).

On fig. 16 is shown a map of a proposed future main line railnetwork in Denmark. This is a minimum network (group p. 135).

On the map to the right is shown the existing 7 domestic airlines from Copenhagen to cities in Jutland.

The following gives an economic comparison of the two systems. If rail shall be able to compete it has to be rebuilt in such a way that the maximum speed can be increased to at least 250 kilometres per hour. It is anticipated that the total travel time by the new fast railway lines will be the same as by aircraft. This means that most of the line in eastern Jutland from Kolding to Randers has to be rebuilt, or actually that there has to be built a new railline as the curves of the old line have too small radii (44). The railway line is also 50 per cent longer than the existing road which, of course, is a handicap in the competition with the road traffic.

In addition it will be necessary to construct a railroad bridge or tunnel across the Great Belt, if rail shall be able to compete with air. The expenses will, with 1968 prices, be as follows:

New or rebuilt railline Fredericia/Aarhus: 110 km	400 million d. kr.
New doubletrack railway bridge across the Great Belt (in connection with road bridge)	800 million d. kr.
Total	1,200 million d. kr.

The following calculation is based only on the Fredericia-Aarhus traffic.

The Copenhagen/Aarhus traffic is 27 per cent of the Fredericia/Aarhus traffic.

Therefore only part of the expense to rebuild the Fredericia/Aarhus line falls on the Copenhagen/Aarhus traffic say	100 million d. kr.
The Copenhagen/Aarhus traffic is only 12 per cent of the rail passenger transport across the Great Belt.	
Therefore only 12 per cent of the expense of the Great Belt railway Bridge is reckoned to fall on the Copenhagen/Aarhus traffic.	100 million d. kr.
Total	200 million d. kr.

Expense for new airport by Aarhus is	80 million d. kr.
This airport also serves other cities in the region, therefore only are calculated on the Copenhagen/Aarhus traffic.	40 million d. kr.

The running expenses of one passenger km is calculated thus (see page 96):

Rail traffic: 0.20 d. kr. per passenger kilometre including interest and depreciation of rolling stock.

Air traffic: 0.40 d. kr. per passenger kilometre including interest and depreciation of aircraft.

One can then make the following consideration to find how big the traffic (Y) must be, before it is "cheaper" to use 200 million d. kr. for railway construction than 40 million d. kr. for a new airport:

It is here reckoned that the railway line across Great Belt is 300 km long, and the direct line for the aircraft from Copenhagen to Aarhus is 200 km long.

Rate of interest is reckoned to be 7 per cent.

7 per cent . 200 million + Y · 0.20 · 300 = 7 per cent · 40 million + Y · 0.40 · 200.

One gets Y = 450,000 passengers per year.

It is anticipated that if a calculation is made for all the traffic between East- and West-Denmark one would get a similar result.

Marshall (1) has made a similar calculation, but with other construction costs for railway line and airport he came to the result that with a distance of 200 km to 300 km between cities air transport will be cheaper up to about 700,000 passengers a year, and with heavier traffic rail will be cheaper. This figure is higher than the 450,000 found above.

The passenger traffic between Copenhagen city and Aarhus city in 1966 was:

By rail:	170,000	passengers per year
By air:	80,000	- - -
Total	250,000	

With the existing traffic level it would then be cheaper to have all the traffic by air than by the rebuilt railway.

The air traffic Copenhagen-Aarhus has been increasing by 19 per cent per year during the last years.

This traffic of course is much lower than the traffic on the Japanese railway lines, which in 1963 worked with a surplus (see page 117).

If a 7 per cent interest of the capital should be achieved, the fares of the new line would have to be increased.

The fare for rail 2' class is 65 kr. and for air: 85 kr. (one way). With 450,000 passengers a year the fares would have to be increased to 100 kr. for the new facility.

With rail and air at the same travel time there is no doubt that rail, even if air connections are kept in service, would take over a very considerable part of the air traffic, such as was the case by opening of the Tokaido line in Japan on the 370 km long distance Tokyo-Nagoya (see page 118).

In the calculation should also be taken into consideration that the fast railway line probably will be able to get some long distance-car travellers to change over to use the rail. Another question is whether the traffic between the provincial towns to a higher degree will go over from car traffic to the fast trains. Fig. 17 shows that with 25 km between stations and 200 km an hour the travelling speed would be 120 km per hour, and with 250 km maximum speed the travelling speed would be 130 km an hour. With 50 km spacing between the stations the average speed would be 150 and 175 km/h and that means that the rail traffic would be more than double as fast as car traffic and therefore would have possibilities for taking over some car passengers.

Neither has been taken into consideration that the new facility would at once after opening create a new traffic of a magnitude of maybe 25 per cent which is reckoned for new motorways in Denmark. The increase of the speed of the railway line will perhaps also increase the freight traffic on the railway line.

The social benefits after that opening of the fast railway line expected to carry all former rail and air traffic it could be calculated thus with an anticipated traffic in the year of opening as indicated:

Time saving:

250,000 rail passengers saving	3 hours each	750,000 hours
250,000 former air -	- 0 -	-	-
100,000 former car -	- 4 -	- 400,000	-

1,150,000 hours of
10 kr. = app. 12 million kr.

Saving on accidents:

100,000 car trips of 300 km = $0.3 \cdot 10^8$ km which causes 0.3 fatalities and 6 personal injury accident per year. These will decrease to $\frac{1}{20}$ (see page 99) or say 0. Saving 6 personal injury accidents of 100,000 kr. each say 1 million kr.

13 million kr.

In the year of opening the social rent of the construction cost 200 million kr. will then be 6½ per cent. Usually, it is however anticipated that the rent should be 10 per cent if a project shall be feasible for construction.

If one anticipates that the rail passenger traffic was totally closed down, the air transportation probably would get some difficulties in carrying all the passengers who want to return by public transport to Copenhagen in one hour during the evening of Easter day. During that hour 12 long-distance trains arrive at Copenhagen central station. They have about 1,000 passengers each. If they should be carried in aircraft, this would mean that, during this hour, 40 aircrafts with about 300 passengers each had to land at Copenhagen airport. This in addition to the other aircraft which have to be served in Copenhagen airport during that hour. As the total capacity with one runway is only 50 aircrafts and with two close parallel runways 70, there would be difficulties for the airport to take over this rail traffic.

Rail traffic is sure to work in all weather conditions better than the air traffic, and that is a point which may be taken into consideration in discussing the case of closing totally the passenger traffic by rail.

All this will argue for no closure of the rail traffic. In this relation must be taken into consideration the rather big staff working for the railway system. It probably would give great difficulties to change them over to other occupation.

If the existing main railway lines are not rebuilt to a maximum speed of 250 km/h, the passenger rail traffic probably will die out as is the case on the American railways.

Also in Sweden the question of closing all main railways has been discussed. In that case as an example all passengers on the main connection Stockholm/Gothenburg would have to use aircraft, if they would travel by public transport. The latest development, however, seems to be an interest in Sweden of rebuilding the railways to a maximum speed of 200 km per hour.

D. THE ECONOMIC CONSEQUENCES FOR DENMARK OF CONSTRUCTING ONE OR THE OTHER OF 2 NEW BRIDGES CONNECTING EAST AND WEST DENMARK

The method mentioned page 101 can be used to calculate the economic development in Denmark in case of the construction of one or the other of 2 different connecting lines between East and West Denmark:

Connection across the Great Belt;

Connection Zealand - Jutland by a bridge across the island of Samsoe;

and our institute is working with this problem.

The calculation so far seems to indicate that the Northern bridge across Samsoe will give the greatest economic development in the country as a whole, but the method does not take into consideration that the Samsoe bridge does not give the island of Fyn better connection to Copenhagen, and it does not take into consideration that Fyn and the Southern part of Jutland in this case get a faster connection with Hamburg than with Copenhagen.

VI. THE FUTURE CITY PATTERN AND THE SYSTEM OF LONG DISTANCE TRAFFIC

According to forecast there shall in the next 30 years, until the year 2000 be built as many dwellings in the world as already exists. Townplanners and humanists such as Doxiades and Toynbee have postulated that this will mean an urban revolution. They expect that chains of metropolitan areas at that time will dominate the world as the population of the metropolitan areas will grow from 3,000 million to 10,000 million inhabitants.

Regional planners have given many thoughts to the problems arising from this expected development. As the automobiles so far as we can see have come to stay one main idea might be that the cities should not be bigger than it is possible for all who want to travel to the city centre by automobile. A calculation shows that the city then should not have more than a 1/4 or a 1/2 million inhabitants.

The metropolitan areas may consist of clusters of such cities.

Of course commerce and industry should be integrated in the new city pattern.

Marshall suggests that such metropolitan areas shall be connected by traffic lines as shown in fig. 18. It is seen that the railline is proposed only to carry freight such as the development in the United States seems to indicate.

The table below compares the 1970 traffic in the networks mentioned in previous chapters. It is seen that the density of transport in networks increases as the area of networks decreases.

Networks	Passenger transport		Goods transport	
	journ./inhab. per year	journ./km^2 per year	t/inhab. per year	t/km^2 year
1. Intercontinental	0.01	0.6	0.5	30
2. European	0.25	16	3	200
3. Danish	20	2,000	6	600
4. Copenhagen	2,000	20,000,000	600	6,000,000

The table also gives figures for town traffic in Copenhagen.

The amount of traffic in network 3 in the table above will in the year 2000 be near the volume in network 4 to-day. As mentioned before an area like Denmark (network 3) will be at that time a town just like Los Angeles to-day.

It is also possible that an area like London-Paris-Benelux-Ruhr will be a "network 2" with traffic like "network 3" to-day. Finally metropolitan chains in North East America, Europe, India, and Japan will form a network 1 with traffic like "network 2" to-day.

In transportation planning it is therefore necessary to work with these visions in mind if a successful planning should be the result.

VII. CONCLUSION

If **declining trend of the passenger traffic on the European railways is to be reversed it seems necessary to increase** the average speed to at least 200 km/h. In this case rail traffic with passengers seem to be clearly faster than both car and air for distances between about 150 km to about 400 km/h and with greater capacity therefore also able to compete with car- and air traffic. It seems indicated that the greatest part of deficit on the railways account is not on the branch lines, but actually on the mainlines.

Air passenger transportation can expect no competition from sea, rail, or road for distances over about 400 km.

Buses will, in intercity traffic, be necessary for non car owners for distances below about 150 km and also for carrying non car owners to the stations. It is anticipated that the fares per km for bus transport is not lower than the fare for rail transport.

For situations where rail and sea distances are equal, rail freight costs are always below those of ships with capacity of 600 containers or less.

Unit container trains with low rates seem an effective way of keeping lots of heavy freight transport over large distances say 4 to 500 km or more away from the roads.

For freight transport any change in the charging of infrastructure cost for the different modes is a complicated problem. Every change will affect the well established rights of the carriers.

Parcel transport might in several countries be rationalised as in the Netherlands.

Where heavy bulk traffic volumes appear pipelines should be considered.

It is the opinion of the authors that new kind of transportation across land, such as air cushion trains, trains in vacuum tube, etc., will perhaps not come into practical use in this century.

More research concerning all these problems is, however, needed, also of the social costs involved with the different solutions, such as accidents, pollution and noise.

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Figure 1

VALUE OF LOST AMENITY IN HOUSES DUE TO ANNOYANCE. (12)

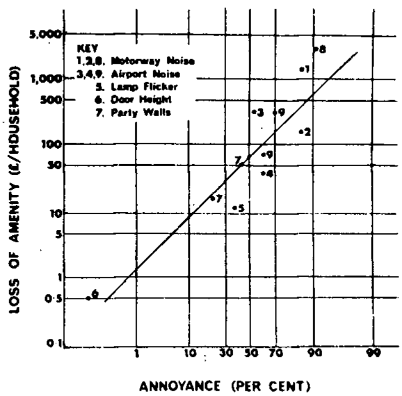


Figure 2

TRAVEL TIME INCL. ACCESS TIME
FOR DIFFERENT TRAFFIC MODES

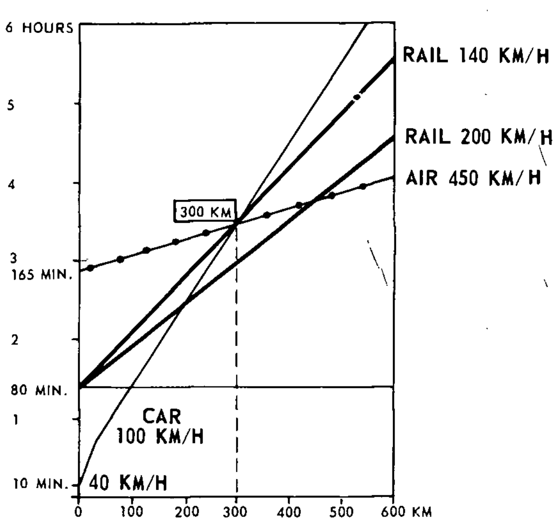


Figure 3

INTERCONTINENTAL NETWORK

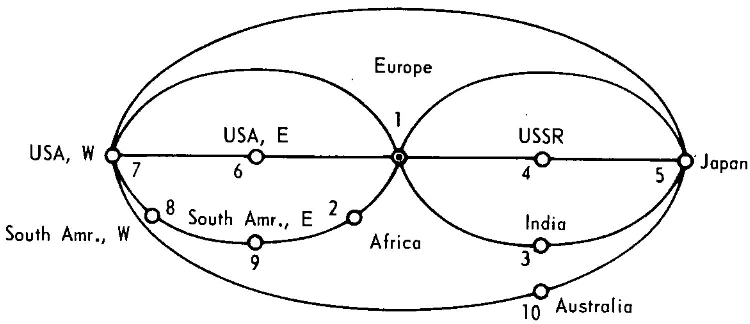
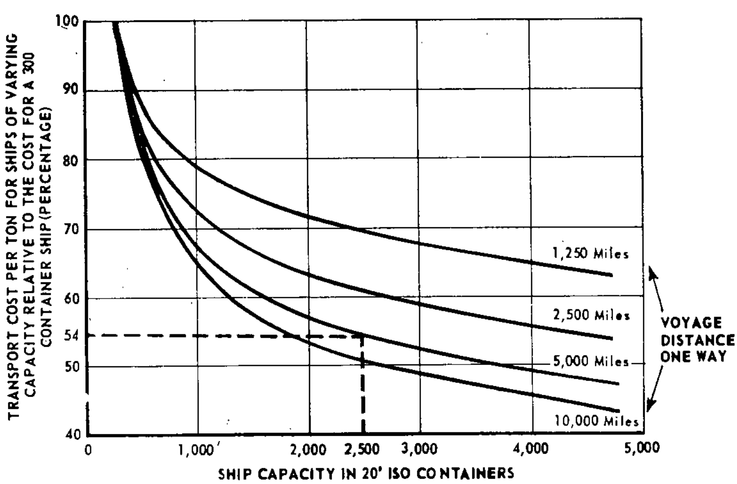


Figure 4

TRANSPORT COST PER TON FOR SHIPS OF VARYING CAPACITY. (6)



Based on a sailing frequency of once per week

Thus, using a 2,500 container ship on a 5,000-mile one-way voyage, unit transport cost is only 54 per cent of that using a 300 container ship.

Figure 5
BREAK- EVEN BETWEEN FEEDER
AND PORT-OF-CALL SERVICES. (6)

(ABOVE EACH CURVE A PORT OF CALL SERVICE HAS THE LOWER COST;
BELOW EACH CURVE A FEEDER SERVICE HAS THE LOWER COST)

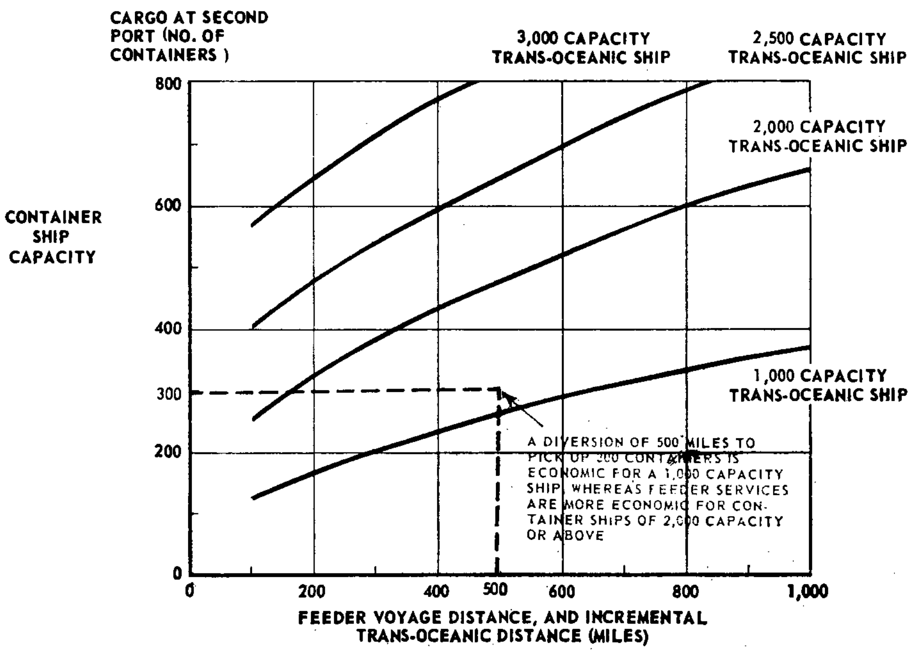


Figure 6

EUROPEAN NETWORK

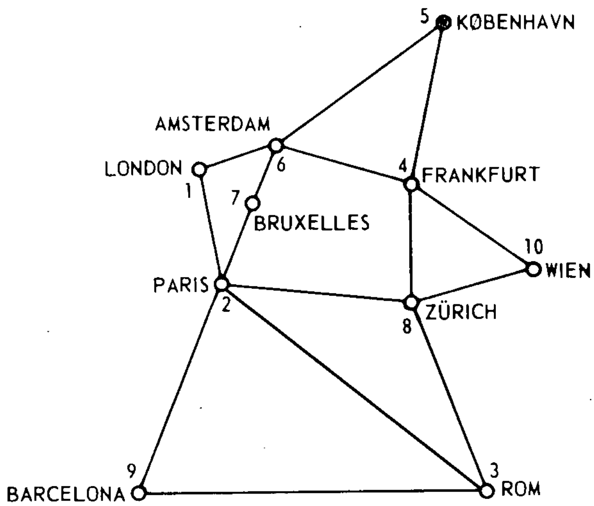


Figure 7

DECLINING RAILWAY PASSENGER Km AS A FUNCTION OF CARS PER INHABITANT

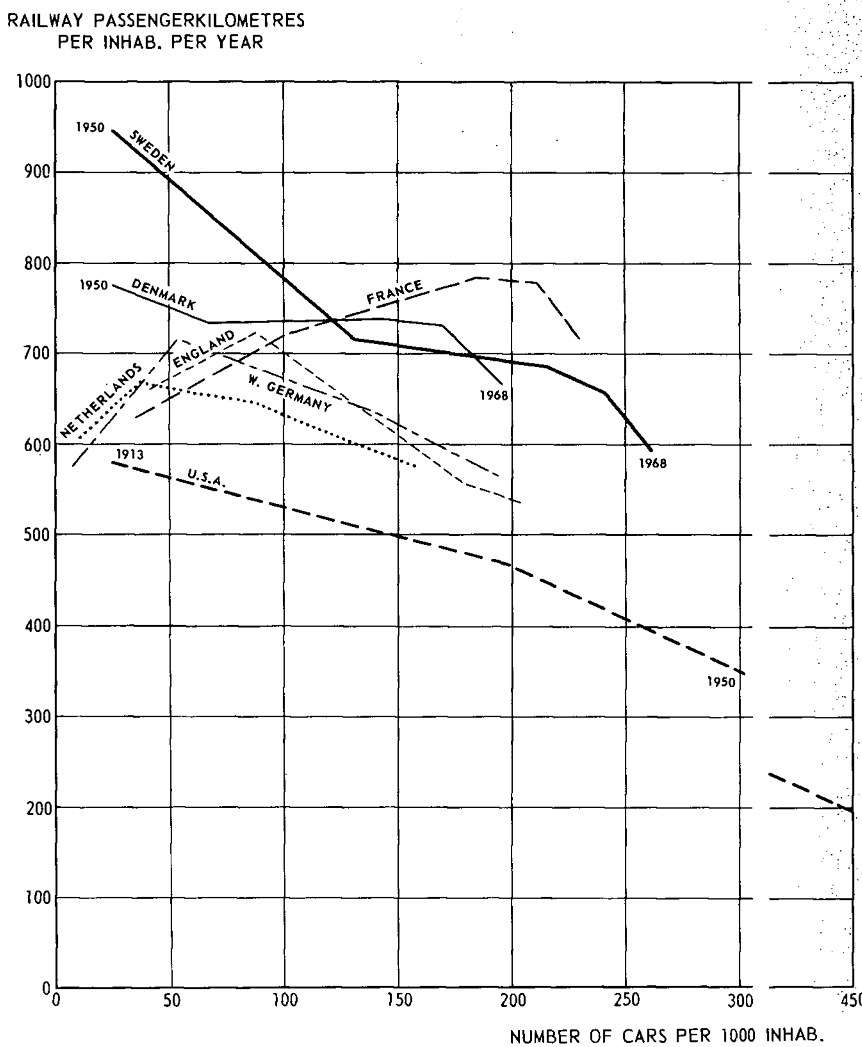


Figure 8

DEPARTURE FREQUENCY AS A FUNCTION OF TERMINALS AND COST. (26)

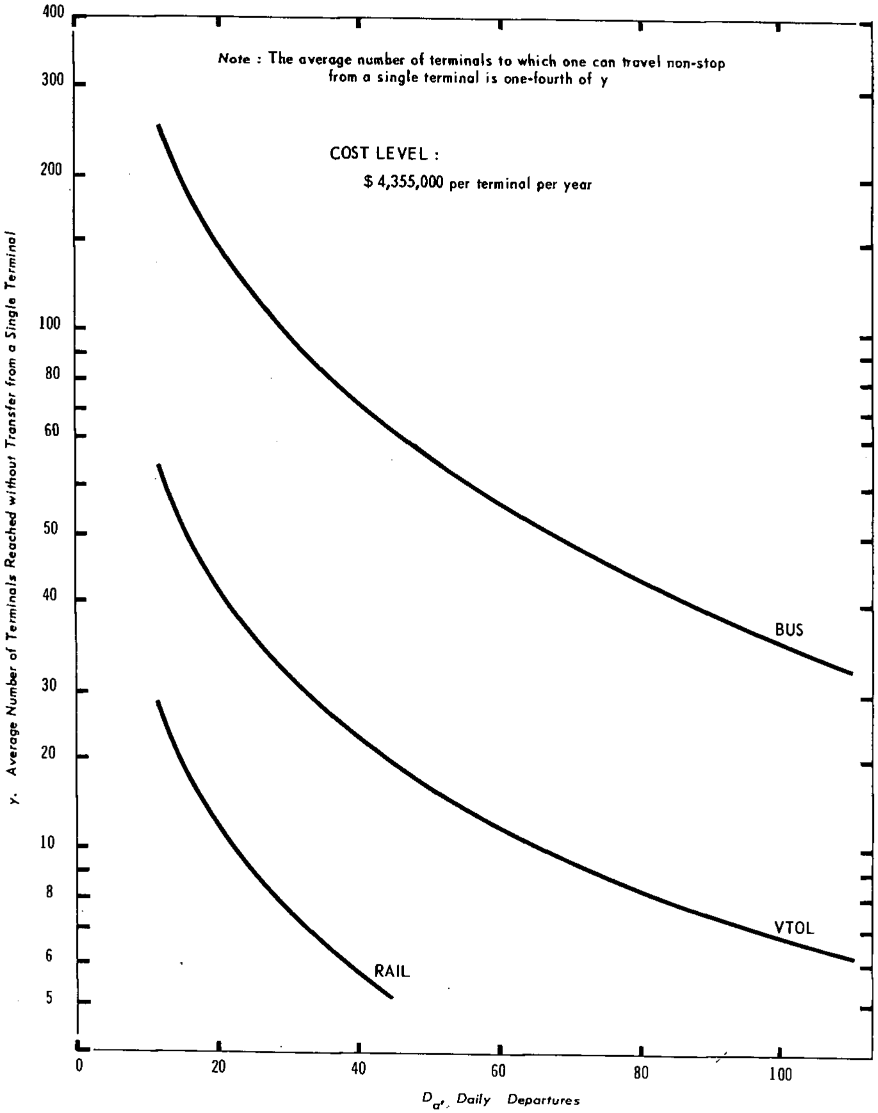
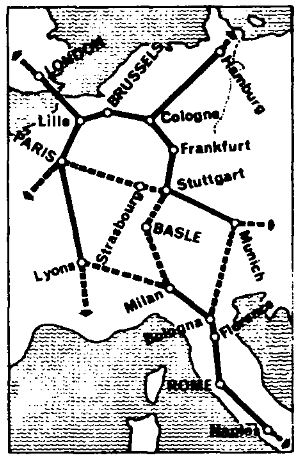


Figure 9

EUROPEAN EXPRESS RAIL PROJECT.
RAILWAY GAZETTE 1970



Railway Gazette International October 1970

Figure 10
DANISH NETWORK

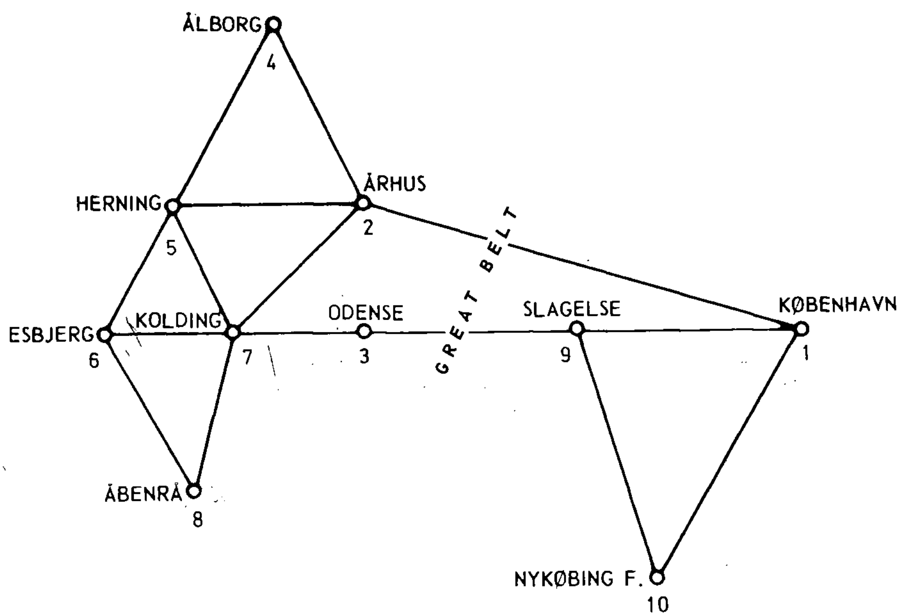


Figure 11

THE DANISH AND THE NETHERLANDS RAILWAY NETWORK

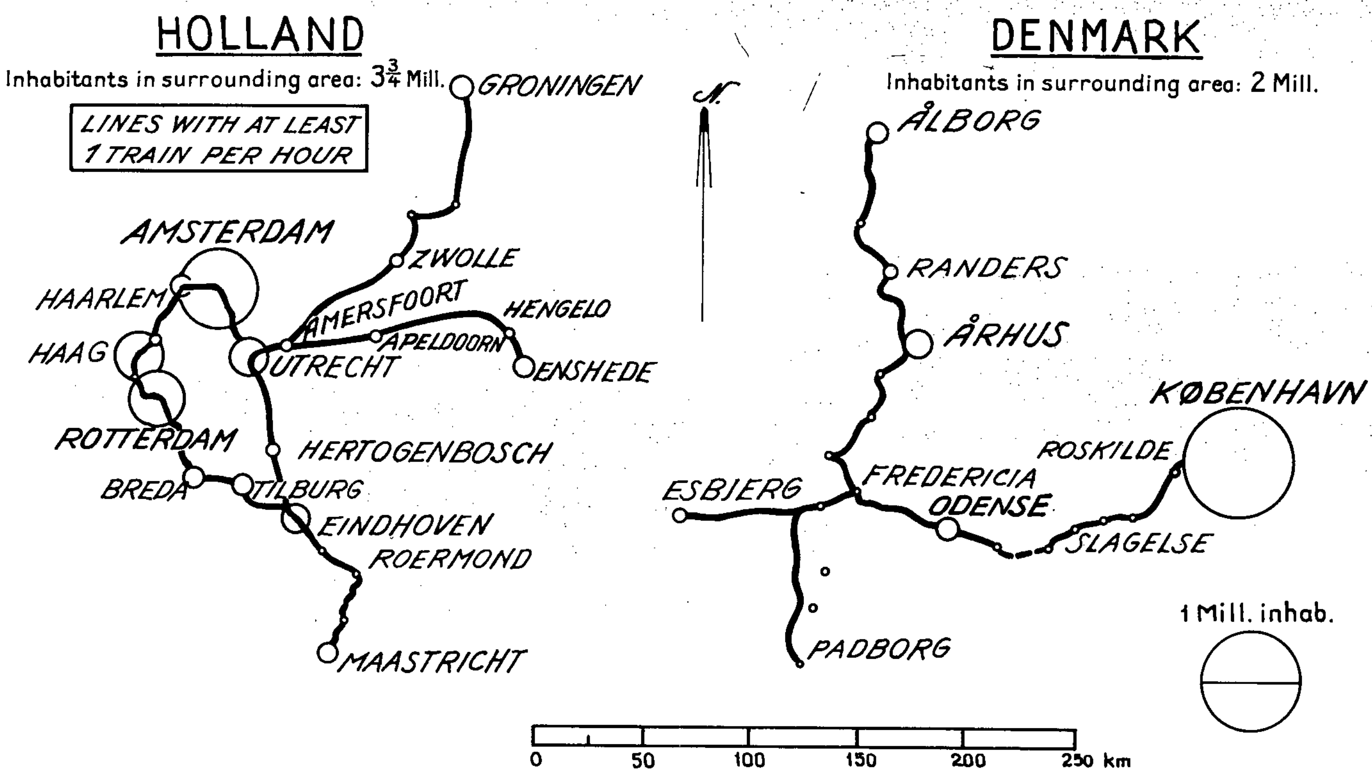


Figure 12

SWEDISH RAIL PASSENGER Km
AS A FUNCTION OF TRIP LENGTHS. (37)

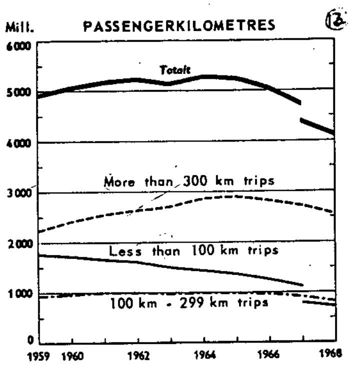


Figure 13

DANISH CLOSED DOWN RAILWAYS

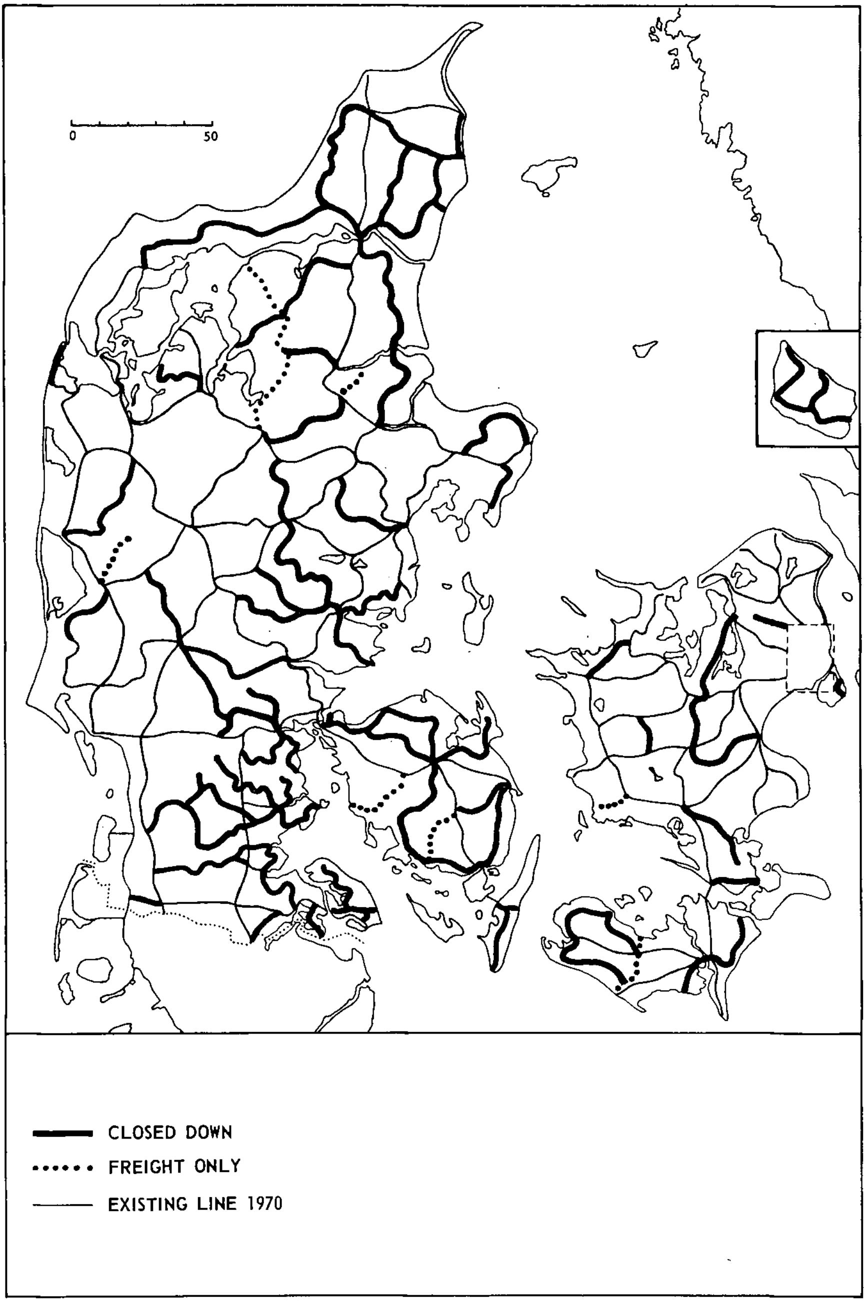


Figure 14

OPERATING AND FIXED COSTS FOR THE RAILWAY LINES IN THE DANISH STUDY AREA. (14)

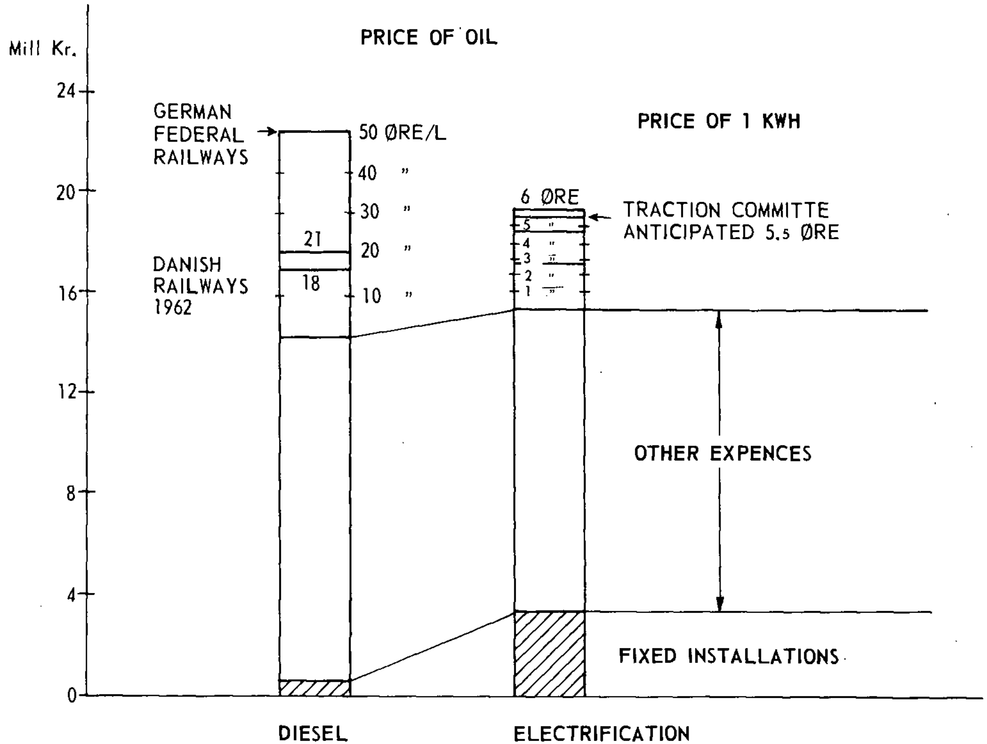


Figure 15

DAILY TRAFFIC 1963

BY ROAD AND RAILWAY IN DENMARK. (43)

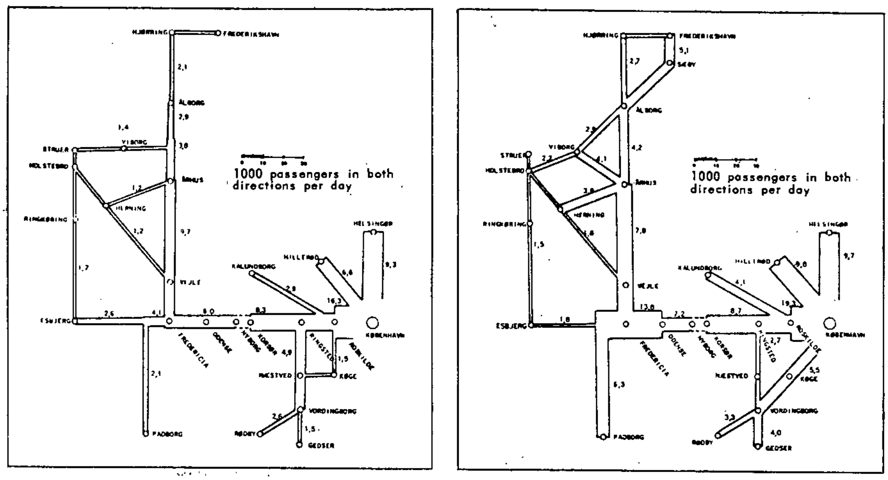


Figure 16

FUTURE RAIL AND DOMESTIC AIRLINE NETWORK IN DENMARK