THE URBAN TRANSPORT PROBLEM AND MODAL CHOICE

By Nathaniel Lichfield and Honor Chapman

We are told, and are gradually coming to understand, that practically all our major technological successes have also been environmental disasters of equal magnitude, and that we are faced with the possibility that our civilisation may be destroyed by its own technological success [7]. Several years ago Buchanan showed us that the private motor car, which must surely count as a major technological success, is a "mixed blessing" [4], and further demonstrated that within existing urban areas the pleasanter the environment the greater must be the curtailment of the use of the private car, a conclusion that was amply borne out in the recent special studies of conservation in our historic cities [10, 5, 15, 35]. The current focus on the environment in European Conservation Year may, rightly, have been primarily on pollution and the decimation of plant and animal life by the overburden of human population; but it is the motor car which, whilst increasing our accessibility and therefore our experience, also acts as a major eroding element not only on the countryside but more particularly on the urban environment.

THE URBAN TRANSPORT PROBLEM

In this article we propose to concern ourselves with one aspect of the general problem of urban transport: that of modal split – the distribution of travellers by mode. For the sake of clarity it is necessary, however, to enlarge on the general problem as a whole.

In essence the urban transport problem stems from an imbalance, under the current "pricing" system for transport, between the supply of transport infrastructure (roads and public transport) and the demand for the use of this infrastructure by an increasing population (for more journeys for both work and leisure). This increasing demand is not being matched by the allocation of sufficient real and financial resources to enable the supply of infrastructure to keep pace, particularly in the centre of cities where the imbalance is most acute and, because of the greater resources required, most expensive. The 1963 Buchanan Report clearly demonstrated the tremendous gap between capital investment in motor vehicles by business and private consumers and in roads and public lighting by public authorities. Even if demand and supply for roads were to be matched under the current pricing system, this Report also showed that for established cities beyond a certain size it is impracticable to provide for the free use of the motor car.

One of the prime criticisms of the Buchanan Report is its lack of realism on the general evolution of our cities at the present time (Beesley and Kain [3]). In its Leeds Study the report assumes that, although greater in volume, the same pattern of
activity will obtain in 1990 as in 1960, so that activities in the city centre will increase pro rata with the general increase in activity, leading to a very acute problem of transport. Beesley and Kain point out that this assumption does not fit with North American experience, which shows rapid decentralisation of activities out of central areas into the suburbs (Meyer, Kain and Wohl [20]). This also appears to be taking place to a lesser extent here in England. The G.L.D.P. survey and analysis [12] demonstrated that Greater London has been rapidly losing jobs over the last few years, while the outer metropolitan area has shown large increases. According to a recent study (Thomas [31]) the same process is under way in others of our large cities – Birmingham, Liverpool, and Manchester. Nevertheless the increase in activity, in spite of this trend towards decentralisation, is now overloading our transport systems.

The seriousness of the problem lies not simply in the need to meet the demands of travellers, but in the wide-ranging impact of the failure to resolve it on urban living as a whole: for example, in the social costs imposed on travellers by congestion and the impact on the economic functioning of the city itself. Mishan [24] has recently highlighted the whole issue by concluding “that the continued pursuit of economic growth by Western societies is more likely on balance to reduce rather than increase social welfare”. He emphasises how the presumed need for economic growth to satisfy the demands of increasing population (which, because of that growth, becomes more affluent) stimulates technological advances which in turn stimulate demand and perpetuate a spiral of growth beyond the point at which community welfare is being increased. In our introductory paragraph we noted the link between environmental disasters and technological advances; Mishan describes these external diseconomies in far more graphic terms. He exposes those of air travel and tourism, and in particular those resulting from the motor car. “The appalling traffic congestion in our towns, cities and suburbs . . . But it needed the motor-car to consummate these developments, to fill our days with glamour and fumes, to suburbanise the countryside and to sub-topianise suburbia, and to ensure that any resort which became accessible should simultaneously become unattractive”. He then goes on to argue that these external diseconomies arising from individual freedoms directly affect the economic functioning of the city itself and thus overall community welfare; and, in the general context, he enumerates a set of conditions which, if met, he contends would ensure a positive relation between economic growth and welfare. Whilst all are relevant, the most pertinent to the remainder of this paper is the second: “that all the measureable effects on other people or firms arising in the production and use of any good – other than those effects which already register on the market mechanism in the form of alterations in product and factor prices – be brought into the cost calculus.”

The problem in urban areas, therefore, is to find a way of satisfying the demand for transport within capacity, cost and environmental constraints. If we take transport to mean accessibility, this is summarised in Buchanan's law thus: “Within any urban area as it stands the establishment of environmental standards automatically determines the accessibility, but the latter can be increased according to the amount of money that can be spent on physical alterations”. Any particular town must therefore attempt to find for itself the appropriate blend of these three considerations within the general context of all its investment opportunities.

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In finding the most suitable blend of the considerations of accessibility, cost and environment for any particular city it is also necessary to consider the means of implementing the subsequent policy, since the blend will be a function of the means of implementation. Where it is decided to restrain the use of vehicles in towns, several means of control are available to meet the objective of achieving the best use of scarce road space. They fall into two groups: physical restraint by means of the supply of parking places and regulation of the use of roads by means of bans and permits, and price restraint related to the place where the vehicle is kept, or the time and place where it is used, or the time and place where it is parked. Alternative means of price restraint are differential fuel, licensing, employment and property charges, and metering the actual use made of congested roads.

The pricing policies would, in part, be designed to make the individual traveller pay for the congestion and other costs he imposes on others, especially at peak periods of demand (Ministry of Transport [21]). It can be shown, as was done in the 1964 Smeed Report on Road Pricing, that in congested conditions some road users impose more costs on traffic as a whole than they themselves gain from using the road. More would be gained than lost if they did not use the road.

Clearly another means of solving the problem is to produce a revolution in the type of transport presently available; but, although new ideas are constantly being produced [33, 22], it appears that the breakthrough has not yet happened. Another solution is for people to use what might be a more efficient form of transport than the private car in the context of community welfare. In other words, because of its greater efficiency in terms of people carried per “unit of transport supplied and consequent lower financial costs of track, vehicles, storage areas and amenity”, they should use some form of public transport, especially for peak hour travel. Although American conditions are not fully comparable with those over here, a parallel policy of attempting to shift travellers from their cars can be seen in the U.S.A., where many transport studies in the last few years have produced proposals for electric railways (mass transit) to assist in carrying heavy commuter loads – but there is doubt whether these are appropriate solutions (Meyer, Kain and Wohl [20]). The reason for this reawakening of interest in public transport is that urban motorways are costly and disrupt established environments, and their use tends to undermine public transport services, since the criterion for running such services is usually that financial revenues and costs (including a profit element) should balance.

The opening up of the means for more people to use their cars by the building of motorways reduces the numbers who travel by public transport and, on this operating requirement, the service itself; where buses are still in use they become subject to the same congestion as cars, and any time advantages over the car disappear. There are always the so-called “captive users” of public transport to be provided for, those who have no car, the old, the infirm and children. The recent outcry, crystallised by the London Amenity and Transport Group (Thomson [32]), against the suggested urban motorways for London, proposals for which were arrived at after extensive study by the transport consultants [12, 37], highlights the difficulty.

In this situation many towns are attempting to find a viable alternative to the unfettered use of the private car. The policy in Leeds is to strive for a balance between the use of public and private transport with the objective of creating and maintaining traffic conditions in which effective bus services are possible. While
greatly restructuring and improving the road system, and exercising control over parking in the central area by limiting the supply of parking spaces and by charging commuters at a level which will be not less than the economic cost of their provision and operation, the city is at the same time improving its public transport services. By traffic management and planning policies it is giving public transport some priority of movement, to make total journey time as short as possible and of the same order of magnitude as door-to-door journey time by private transport. In addition to its normal bus services, the city plans to develop non-stop express bus routes on primary roads between home and work, small city centre buses for short movements within the central area, and park-ride services from outer suburban interchange points to the central area.

The essential policy in Leeds is that the scale of the primary road system is dependent on the limitation of private access for work journeys. The degree of limitation must leave sufficient residual demand to make it possible to operate an effective public transport service as an integral part of the whole plan. The quantification of this policy was based on a joint study with the Ministries of Transport and Housing and Local Government [16]. Leicester has a similar policy with its (by now famous) city plan based on greatly enhanced bus services, a park and ride system into the city centre, and possibly electric cars for personal transport within the central shopping area. In order to make the bus service attractive it is purchasing new air-conditioned, double-glazed, air-sprung buses with specially comfortable seats – in fact, attempting to make the bus as comfortable as the car [28]. And several other cities and towns are making similar studies or trying out new ideas for public transport.

MODAL SPLIT

Whatever innovations are introduced into public transport, the difficulty is to forecast whether or not people will use public as opposed to private transport for their trips – or, in the words of Wilson [36]: “to investigate the causal factors influencing travel demands for the existing situation and to examine them in relation to future conditions in an urban environment and to assign this demand to the various modes of travel available within the area”. Both Wilson, in his development of a mathematical model based on research and surveys in Coventry and Greater London, and Quarmby in similar research in Leeds [25] infer that modal split is probably the least satisfactory part of current transport studies. Both review previous work in this field, almost all of which has been done in the U.S.A., and Quarmby classifies it in three ways: “Firstly, there is the type of study which relates the use of public transport throughout a city to such characteristics as size, density and age of the city, and to population characteristics such as income, car ownership, and so on. Secondly, there are models of mode choice developed by North American transportation consultants as part of their comprehensive travel forecasting procedures: typically the aim is to predict public transport and private car use for all trips made between any pair of the zones into which the urban area is divided. . . . Thirdly, some researchers have developed models to explain and predict individual choice of mode, taking account of individual travel and household characteristics”. What is important
and "new" about the model of modal choice that Quarmby then goes on to develop, based on methodologies developed by Warner [34] and Beesley [2], is "that any theory of modal choice should be able to take account of planning or policy variables as influences on modal choice, and secondly, that any hypotheses implicit in such theories should be plausible in relation to individual travel behaviour". Thus Quarmby took into account elements such as journey time, journey cost, income of travellers, availability of car at work, and so on. There are many more such elements of more or less determinative value for modal split, as evidenced in a study by the U.S. Highway Research Board [14]. Potentially the aim would be to isolate the prime variables influencing travellers' modal choice and then to alter the characteristics of the modes available that public transport becomes relatively more attractive to travellers than private transport, at any rate in peak periods. Examples are the attempts in Leicester to make the buses more comfortable, and the adjustment of total journey time by restricting parking so that the car takes longer to park.

But while work is still proceeding on predictive models of modal split with an eye to finding the key elements to influence more people to use public transport, especially at peak periods, the vital question is: If some people are persuaded to use public transport in preference to their cars as a more efficient solution to the urban transport problem in engineering terms, will the community overall be better off?

This is the question we set out to answer by means of a cost–benefit study of alternative modal splits in Stevenage. The results of our study have recently been published [19]. Since our conclusions are of general relevance to the whole urban transport problem, and especially to problems connected with turning transport studies into viable plans for transport investment, we propose to describe the approach and findings in this paper.

STEVENAGE NEW TOWN: A CASE STUDY

The problem facing a long-established town is to modernise an outdated transport system. The issue has also arisen in the "New Town" of Stevenage, which is only about 20 years old, with a present population of about 70,000. The 1966 Master Plan for Stevenage typifies one-half of the fundamental choice facing all our towns and cities, since it describes the town as it would appear if the emphasis were to be placed on the unrestricted use of the private car.

During the preparation of this plan forecasts were made of the likely amount of traffic on the roads at the end of the century, when Stevenage will have a population of about 105,000. It was assumed that by then 45 per cent of the inhabitants would own cars, and that they would use them in preference to public transport: in preference, that is, to a bus system similar in style and frequency to that now run in the town by London Transport, a familiar system of double-deckers with problems of frequency and operating economics similar to those in other towns. These forecasts were then translated into a road system which would carry, with reasonable ease, both buses and cars to and from work during peak hours and throughout the town during the day. This system, complemented by the network of footpaths and cycleways which is unique to British New Towns, could cater for traffic by extending the present ground level roads until 1976; after that date elevated roadworks would be required, particularly at intersections.
These elevated roadworks would cost an extra £4.5 million and be less attractive to look at than roads at ground level. The expense of the system would fall not only on public funds, which would provide the roads and multi-storey car parks, but also on employers, who would need to build car parks for their employees, sterilising land for potential expansion, particularly in the industrial areas.

In these circumstances the Development Corporation decided to consider whether a really good public transport service, designed with the emphasis on passenger attraction, would be better for the community as a whole than building the additional roads. Such a service could reduce the volume of private cars used at certain times of the day. But, more particularly, it could reduce the use of cars for the peak flows to and from the industrial area and town centre which are, and will increasingly be, the prime source of the traffic problem in Stevenage, as in other urban areas.

To help it to reach a decision the Corporation in 1967 commissioned economic consultants, Nathaniel Lichfield and Associates, to collaborate with its officers and consultant architect and planner in preparing an analysis and report.

Early in the study the London Transport Board, the Ministry of Transport and the Ministry of Housing and Local Government were consulted. All gave generous help. After discussions their representatives joined with the economic consultants and the Corporation’s officers and consultant architect and planner to form a working party, with London Transport representatives as members and the Ministries’ representatives as observers.

The principle followed during the preparation of the study was that the officers and the consultant architect and planner of the Corporation and London Transport should be responsible for the formulation of the alternative choices of transport systems open to the Development Corporation and for the preparation of data on these systems; that the economic consultants should be responsible for preparing the various comparative analyses of these systems; and that the observers from the Ministries should provide advice and further data as they thought necessary. These responsibilities were not considered to be mutually exclusive, and there was a substantial amount of discussion between all members and observers on the various elements comprising the study.

Hypothesis on Modal Split

The essential comparison to be made in the analysis was between hypothetical distributions of travellers by mode: the modal split. These hypotheses crystallised into three alternative schemes, all of which used the modern bus – basically as described above for Leicester – as the form of public transport.

Other forms of public transport were considered for Stevenage by the officers of the Corporation and London Transport. Forms of a “fixed line haul” type, such as the train, monorail, minirail, buses on own right of way, moving pavements and guided track hovercraft, were rejected. A horizon population of 105,000 might have justified the capital cost if the form and structure of the town had been shaped to one of these systems; but the dispersed nature of Stevenage, resulting in low trunk flows and relatively short journeys, and the difficulties of “fitting in” such systems to the existing structure, would make them prohibitively expensive in both financial and environmental costs. The choice lay between systems of the “variable line haul” types – bus, coach, minibus and jitney (minibus which stops on command with no
fixed stopping places) — and the “diffuse” types — taxi and automated jitney (minibus with door-to-door taxi-type service, routed by computer). All these could use the ground level road system and would require no capital investment in fixed track. In the event, after consideration of the capacity of the ground level road system, the nature of the demand for journeys and the economics of operation, modern buses of a reasonably high capacity were chosen.

The first scheme was that devised by the Corporation officers. Briefly, travellers would be carried by an express bus service with limited stops, with an average walking time to and from the stop in residential areas of 3·3 minutes, routed along the primary roads from 14 terminal points in the residential areas at a prime frequency of five minutes. During peak periods most services would go direct to the industrial area. At other times routes would generally terminate at the town centre, connecting with a loop service through the industrial area. This basic service would be augmented by a public charter service, called a Peoria type service (after the place where it originated), running directly between the residential areas and the factories. Buses would run along the same routes as the basic express service but would have the distinctions of pre-booked seats, specific pick-up times and hostesses to assist passengers. The completed system of ground level roads would require one elevated section to maintain common standards of free flow; and there would be multi-storey car parks in the town centre and ground level car parks in the industrial areas.

London Transport had reservations about the enhanced bus service proposed by the Corporation’s officers, and instead of the express services proposed a number of circular routes, all of which would pass through the town centre, giving a wider coverage of the residential areas with more frequent stops and a lower average walking time to and from the bus stop of 2·5 minutes. The prime frequency would be 10 minutes. As in the Corporation’s scheme, the basic circular routes would be extended or diverted at peak periods into the industrial areas, with the “loop” service between the town centre and the industrial area during background periods. The basic service would again be augmented by a direct Peoria type service between the residential areas and the factories; but this would be on a larger scale than in the Corporation’s scheme and would be a door-to-door service with pick-up within a hundred yards of the traveller’s home. This scheme would require the same road system as the previous scheme but a slightly greater number of car parks.

Both London Transport’s and the Corporation’s schemes proposed an enhanced bus service to encourage the traveller to use public transport in preference to his car. The scheme implicit in the 1966 Master Plan (called the private transport scheme) would do the opposite. When the ground level roads were completed in 1975, further capacity (to take the demand forecast from unrestricted use of the car) would be obtained by building eight sections (instead of one) of elevated road, together with multi-storey car parks in the town centre and extensive ground level car parks in the industrial area. There would also be a “residual” bus service, and for the purposes of comparison in our analysis London Transport scaled down the enhanced bus service of its scheme to represent this residual system at a reduced prime frequency of 15 minutes. This scheme estimated that 60 per cent of work journeys would be made by car in 1995, drivers carrying 15 per cent of travellers as passengers; 12·5 per cent would be made by bus, and the remainder on foot or bicycle. In other
words, predictions of bus usage were based on the residue of travellers remaining after those who had and wished to use their cars, cycles or feet had done so—a familiar approach of transport studies.

Both the public transport schemes assumed that there would be a form of back pressure or control exerted on potential car users, as there would be a limited supply of parking spaces at destinations, so that travellers would be to a certain extent edged on to the buses; and also that the new services would be so attractive in journey times, standards of comfort and convenience, and fares that travellers would choose the buses in preference to their cars. But there was some divergence in the basis of the two predictions. London Transport predicted use of buses by a residue of travellers after all the available parking spaces had been taken up by commuters into Stevenage, and by motorists who would still prefer to use their cars wherever parking space would be available at a reasonable price and degree of convenience. The Corporation based its predictions on detailed experience and knowledge of traffic movements in Stevenage, and on experience in changing the modal split by the effective creation of a cycleway primary network.

The Corporation predicted that 35.5 per cent of work journeys would be made by bus and 37.5 per cent by car, while London Transport predicted 31 per cent by bus and 44 per cent by car. Both assumed that cycling and walking would increase. Initially this might appear to be inconsistent, since what distinguishes the public transport schemes from the private is the addition of public transport opportunities to the same number of private cars (since car ownership was assumed to be the same for each scheme), some buses, cycling and walking. On the face of it, the addition of more public transport opportunities could not be expected to make travellers divert to cycling and walking. But the officers of the Corporation and London Transport considered that the restriction on car usage would cause transfers not only to public transport but also, especially for shorter journeys, to walking and cycling.

In all schemes the current system of road usage and financing was assumed to remain. Therefore no proposals were put forward for altering modal splits by road pricing, differential fare systems, parking charges, or other price adjustments.

In formulating their modal splits both sets of officers made assumptions either explicitly or implicitly about the relative weight travellers would attach to the characteristics of the modes being offered to them.

The following explicit assumptions were made about Stevenage and the three schemes for the purpose of the analysis:

(1) The modal splits put forward by the officers of the Corporation and London Transport were taken as the best predictions that could be made at the time of the likely usage by travellers of the alternative modes of transport available. They proposed only a modest increase in the use of the bus, but this would be sufficient to avoid the need for elevated roadworks. An analysis was made of the amount of “leeway” on the modal split on traffic (not cost-benefit) grounds. This showed that, assuming the numbers of cyclists and pedestrians and the car occupancy rate remain constant at the levels predicted in each of the schemes, there would be scope when the town was completed in 1995 for 13 per cent of travellers by all modes in the Corporation’s scheme and 7.5 per cent in the London Transport scheme to switch into cars before there would be the need to build elevated roadworks. However, if the car occupancy
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and numbers of cyclists and pedestrians remained constant at the lower levels assumed in the private transport scheme, then the reverse applied, and 10.5 per cent more travellers in the Corporation’s scheme and 15 per cent in London Transport’s scheme would have to transfer to the buses to avoid the need for elevated roadworks.

(2) Free flow conditions would prevail. It is a policy of the Corporation that the road system will be designed to such a capacity in each scheme that traffic will be able to flow freely – buses will be able to maintain their running times for every trip and there will be a high degree of freedom and access for the private motorist, cyclist, moped rider and pedestrian. The Corporation’s officers consider that, although there would be different costs of congestion between the two public transport schemes because more people would be driving cars in the London Transport scheme (30 per cent of the workers as opposed to 25 per cent in 1995), the capacity of the road network would be such that these can be assumed to be insignificant. Similarly the private transport scheme will have such capacity that the average speed for private cars is assumed to be the same for the three schemes throughout the project period.

(3) The level of car ownership would be the same and would increase in the same fashion for all schemes throughout the project period. Capital investment in cars, garages, visitors’ parking spaces, petrol filling stations, etc., were therefore assumed to be common to all schemes.

(4) Average trip lengths by various modes for various purposes between origins and destinations would be and would remain the same for all three schemes throughout the life of the project for those trips that were quantified. The Corporation’s officers considered that, although these journeys might lengthen as the town expanded, the alteration in average trip length would be insignificant.

(5) The schemes were technically feasible and reliable in terms of engineering, operational, financial and budgetary considerations.

For the purpose of the study the Corporation’s officers were able to predict and quantify, on the basis of their research for the Master Plan 1966, the numbers of trips by all four modes between home and work, home and school, home and the town centre for shopping and recreation, these being primarily peak hour flows. But they were unable to quantify other trips for various purposes which constitute background flows throughout the entire day. Thus the study covered quantitatively about 48 per cent of the total trips made at present, but almost 100 per cent of peak hour trips. Because background traffic is likely to increase faster than these peak hour trips, the trips quantified may fall to as little as 20 per cent of the total by 1995. A great deal of data was available to the Corporation’s officers from their previous research on the use of the town’s highway system as described in the Master Plan and Traffic Accident Survey ([29, 30, 1]) as well as from a survey carried out in Stevenage by the Department of Transportation in the University of Birmingham [6]. In addition the Corporation’s and London Transport’s officers carried out further research specifically for the study. So our analysis was based on a reasonably accurate picture of the future pattern of transport in the town, although many of the estimates had

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perforce to be crude approximations because of the extremely detailed nature of the predictions to be made – for instance, on parking times and the times of day at which people would travel.

**Approach to the Study**

Since the public transport systems postulated were intended to be very attractive to travellers in order to divert them from other modes of transport, these systems represent an "ideal" which has not yet been introduced into Stevenage in practice. Accordingly there is no evidence to show how attractive these systems will prove to be to the people of Stevenage. They can only be regarded as hypotheses, by people experienced in these matters, of the behaviour of various sectors of the community in the event of the proposed transport systems being implemented.

Our analysis was therefore not designed to decide which of these hypotheses is correct in the sense that it predicts what will happen in fact. The analysis merely sets out the social costs and benefits that would flow from each, in an attempt to show which would confer the greatest net benefits on the community. In so doing, it analyses the behaviour of the various sectors of the community about whom predictions were made in formulating the schemes, to ascertain the costs and benefits to them of behaving in the way predicted.

Given engineering and planning feasibility, the choice between the alternatives could be made simply on the basis of the financial costs and returns to the agencies responsible for constructing the roads and car parks and for running the bus services: the Ministries acting through the Development Corporation, industrialists and London Transport. The criterion would be financial: minimum cost for a given return, rate of return on capital invested, or net present value of expected costs and returns through time.

Important as it is, such a financial comparison is inadequate as a basis of decision-making by a public authority, simply because it does not reflect the wider repercussions of a transport system on all sections of the community. These repercussions include the visual effects of elevated roadworks on people of the town as a whole and in particular on the occupiers of buildings nearby, different costs in time spent by travellers making journeys on the alternative systems, different accident costs, etc.

Thus the need is for a form of analysis which compares the wider repercussions of the systems in terms of advantages (benefits) and disadvantages (costs) to all sectors of the community affected. Social cost–benefit analysis is such a form. It has been devised to aid the taking of decisions, principally investment decisions, between alternative courses of action where public decision-makers are concerned not merely with the financial profits of individual undertakings but also with the direct and indirect repercussions of their investments on other sectors. In particular it has been developed in recent years in the field of highway and public transport investment, the Victoria Line Study being a well-known example [11].

A social cost–benefit analysis is distinguished from a financial analysis in various ways. It takes into account social as well as private costs and benefits, such as accidents and journey times. It is concerned with real as opposed to financial costs: that is, real resources used up by the community in the production of goods and services, excluding payments such as government grants and subsidies which are merely transfers between different sectors of the community and do not use up real resources.
But even this wider analysis does not fully take account of all the advantages and disadvantages to the community of the alternatives, since it is normally confined to items that are measurable in money terms, and therefore excludes indirect impacts which are intangible in the sense that means have not been devised for so measuring them: for example, the money value (if any) of driving along a beautiful as opposed to an ugly route. In highway and transport cost–benefit analyses, specifically, the only social costs and benefits that have been measured and therefore included in the analysis relate to accidents, journey time, car operation and, sometimes, comfort and convenience.

The application of social cost–benefit analysis has been extended in urban and regional planning to cater for this wider concern and to include intangible costs and benefits as well as those that can be measured in money terms. The analysis is known as the planning balance sheet ([17, 18]). Its prime purpose is to show the impact of the alternatives on all the affected sectors of the community by bringing out the differences to them in terms of both measured and intangible costs and benefits. Thus such items as the intangible costs of flexibility and trip amenity are considered along with the measured costs usually included in a conventional highway cost–benefit analysis. Furthermore, since planning analysis is directed to equity as well as efficiency, the planning balance sheet is also concerned with the incidence of cost and benefit. Accordingly it indicates the incidence of transfer costs, although it excludes them from the assessment of the net impact on the community as a whole.

Our report therefore consisted of two closely interlinked but separate accounts:

1. The Planning Balance Sheet, which is concerned with social costs and benefits, and is ultimately divided into:
   (a) The measured analysis of costs and benefits which are measured in money terms (social cost–benefit analysis) and
   (b) the unmeasured analysis of intangible costs and benefits which are assessed by means of a points system.

2. The Financial Operating Analysis, which is concerned with financial costs and benefits to assist the Corporation with its budgeting and financial programme.

The essence of the balance sheet technique is to consider the alternative schemes from the point of view of the sectors of the community who would be affected by the choice of scheme. These are divided into producers/operators and consumers—individuals or groups who play a part in creating and running the services to be realised from the project, paired as far as possible with the appropriate consumers. In this study the sectors were: producers/operators of the highway and public transport system (the Corporation, the Ministries of Transport and Housing and Local Government, the local authorities, London Transport and car owners) grouped together, paired with the travelling public (consisting of regional and local through traffic and Stevenage travellers); and the Development Corporation as landowner, paired with current occupiers. Since there would be no displacement there was no need to split this latter pair into those landowners and occupiers who would be displaced and those who would not.

The objectives, called instrumental objectives, are then enumerated for each sector. In some cases sub-objectives are also enumerated to enable costs and benefits
to be traced more accurately and thus to define the impact of the alternative schemes more closely.

Since the quantified trips were for the same purposes and to the same destinations in each of the schemes, we assumed that there would be equal global benefits for each scheme to be realised at the price of the inputs necessary to make the journey. Thus our criterion for choice was the minimum total cost for a common benefit. Therefore all the instrumental objectives were expressed as "minimising costs". In this respect the analysis differs from that of conventional cost–benefit analysis, where cost savings are usually treated as benefits.

The instrumental objectives we enumerated were for:

**Producers' operators of the highway and public transport system:** minimum cost of real resources consistent with the overall engineering and planning standards to be achieved.

**The Development Corporation as landowner and current occupiers:** minimum net cost from loss of amenity. Occupiers of standing buildings may experience real changes simply from the impact of the changed road system, in the quality of the services they enjoy, such as accessibility, use of adjoining property, noise, visual amenity, privacy and so on. Such changes in occupational quality lead to changes in economic rent, since differentials in relation to other buildings are altered, and later perhaps to changes in contract rent or price. For landowners these are again transfers; but for occupiers there are real changes in cost and benefit, and the objective is to minimise the net costs. In Stevenage the distribution of routes and relationship of houses to the road system will be the same for all three schemes; the only quality that is likely to be changed differentially is the visual and occupational amenity of the dwellings.

**Travelling Public:**
1. Safety – minimum cost from accidents.
2. Time – minimum cost of time spent travelling.
3. Mode quality – pleasantness and suitability of mode of transport. This can be divided into:
   (a) overall standards of comfort and status;
   (b) amount of personal effort involved;
   (c) use of journey time;
   (d) opportunity for healthy exercise;
   (e) freedom from harmful effects to health;
   (f) convenience;
   (g) flexibility.
4. Trip quality – pleasantness and suitability of the transport system. This can be divided into:
   (a) choice;
   (b) environment.

The objectives for travellers were linked with the original design criteria considered when the systems were designed. By adopting these criteria as instrumental objectives...
it was possible to test the systems against the original qualities set up as "ideal" by the authorities who would be producing and operating the services. The important point is that these objectives for travellers are intended to be most of the criteria which, in our judgment, an individual takes into account, explicitly or implicitly, in deciding how to make a journey. Financial costs of car park charges and bus fares are excluded from the analysis because they are transfer items from one sector to another and do not use up real resources, and car operating costs were included for car drivers as producers/operators of the highway and transport system. These objectives are directly related to some of the variables used in Quarmby's third category of predictive models of modal choice, and to his own model, in which individual travel characteristics are used.

The costs and benefits flowing from these objectives were then computed over the assumed economic life of the project, which we took to be about 50 years, for each scheme and then discounted back to a common base date: 1975, the date at which actual work on the building of elevated roads would have to begin if the private transport scheme were adopted. In discounting, the rate of interest chosen can have a significant effect on the results; we adopted 8 per cent, the rate then laid down by the Government for the nationalised industries to be broadly consistent with the "average rate of return" in real terms looked for on low-risk projects in the private sector in recent years (Cmd. 3437). Since it is doubtful what is the "correct" rate and how sensitive the outcome is to the timing of costs and returns, 4 per cent and 10 per cent were also used to assess the "sensitivity" of the outcome to the rate selected. We also ran the analysis for an alternative economic life of 30 years.

While it is possible to measure most of the producer/operator costs in money terms, many of the consumer costs, being indirect, cannot be so measured. An increasing amount of research has been and is being carried out into methods of measuring several of these non-market costs and benefits, and where well-established techniques were available we used them; for example, for costs of travellers' journey time and accidents. All measured costs were at constant 1967 prices. Capital and annual operating and maintenance costs of the road system, bus services and cars were estimated for producers. Costs of accidents to consumers were estimated on the basis of Road Research Laboratory figures [26], which are based on the loss of future output net of consumption of the persons killed, costs of the diversion of current resources for repairing vehicles and other property, and costs of medical treatment and administration. These figures do not include anything for suffering and bereavement. Time costs were assessed on values recommended by the Ministry of Transport [23] for non-working time, based on a review of various research projects undertaken both here and in the United States on how people value non-working time and related to the national average gross personal incomes of earners. It has been observed [25] that people appear to value time spent on walking, waiting, parking, etc. - trip-end time so called - at about twice as much as time spent in the vehicle or on foot where the entire journey is made in this way; we accordingly estimated and valued separately for trip and trip-end time. Thus the entire door-to-door trip was taken into account.

The Corporation's officers carried out research into the time spent parking in industrial areas, where parking conditions now are similar to those that will obtain in Stevenage in the future, as well as studies of trip-end time at the home end of the
journey. They found from observation of vehicles entering factory car parks at Hatfield that on average a driver takes 2 minutes 45 seconds from passing through the entrance to arriving at the factory door. They also observed that drivers enter the factory up to 30 minutes before the starting time, and that entry continues until after the nominal start of work. It is apparent therefore that for a variety of personal reason workers voluntarily utilise a quantity of their own time within the factory premises. It is thought that in some cases this is an attempt to avoid the traffic congestion that would inevitably occur if they attempted to arrive later. Also drivers from longer distances may make allowances for uncertain times of arrival. In addition the requirements of passengers could necessitate early arrival. It is estimated that the average driver passes through the factory entrance approximately 12 minutes before commencement of work, and therefore utilises about 9 minutes for his own requirements. We defined this nine minutes as “personal time” but did not include it in the calculation, since we did not know how it varied between car parks of different size, and because bus travellers could equally well arrange their journeys to provide an amount of personal time at work, and without equivalent data the comparison would have been invalid.

Costs related to the travellers’ objectives of mode and trip quality and landowners’ and occupiers’ objectives of amenity could not be measured in money terms. They were valued by means of a subjective points scoring system which attached a quality score to each mode for each sub-objective and then translated it into a quality score for each scheme for each objective by multiplying by the numbers of people using that particular mode in each scheme. A similar process was followed for trip quality. Objectives which had been measured in this way were ranked in an assumed order of relative importance; so were the sectors. The results of alternative sets of weights were shown in order to test for sensitivity and to show to the Corporation the implications of alternatives. The points allocated have no direct relationship to money values, and serve merely to distinguish preferences between schemes on intangible items alone. The points at all times were based on our own subjective judgment of relative differences between schemes and relative orders of importance of sectors and objectives. Although these judgments were checked with the working party and with research where available, they remained largely our own. Sets of judgments other than ours were shown in the alternative sets of weights. We finally made an analysis in qualitative terms of those trips we had been unable to quantify to see how they might affect the results of the quantified analysis.

Conclusions of the Analysis

We presented our conclusions from our analysis by posing five major questions in amplification of the simple initial question put by the Corporation when it commissioned the study (Should it facilitate the use of cars in Stevenage by building the elevated roadworks and supplying only a minimum supporting bus service, or should it encourage travellers to use public transport by supplying an enhanced, fast, modern, and convenient bus service, thus eliminating the need for the elevated roadworks?). Our report gave a fairly firm indication that on the hypotheses and data set out the latter course would be preferable in the general community interest. This was amplified in the answers to the following four questions.

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(1) Would the travelling public use either of the two bus systems which have been devised to the extent predicted in the report? As pointed out above, we were not attempting to answer this question, but rather to decide whether it was worth while to conduct further research in this field in an attempt to influence people's mode choice. Until this had been demonstrated the precise extent of likely public use was an academic question. Since the study has shown that if diversion from the use of the car to the use of the bus is feasible it is also desirable in the general community interest, we recommend that the informed hypotheses of modal split underlying the two public transport schemes could be tested by means of a project linked to a demonstration scheme.

The proposed demonstration-linked studies would also throw more light on the relative advantages and disadvantages of the two alternative bus services. The analysis showed that these two systems appeared to be evenly balanced, each having advantages and disadvantages compared with the other. From our study, whilst the Corporation's scheme would appear to have the edge, it is not possible to be certain whether this scheme would in fact be the better. An essential factor in this comparison is the preference which would be exercised by the people of Stevenage for one or the other.

The Corporation and London Transport had already been holding consultations with the Ministry of Transport on the question of a demonstration scheme for the Peoria service, and this service is now running in the town between one of the neighbourhoods and the industrial area in the morning and evening peaks. At the same time Professor Smeed's department at University College is running a parallel research project. Consideration is also being given to a more ambitious demonstration scheme and research project.

Demonstration schemes on their own are of very little value without the concomitant research. The intention of the research in Stevenage is to work within the framework of our study to try to establish, by measuring the numbers of people who use the new service and finding out what induced them to leave their previous mode of transport, whether the original modal splits hypothesised would obtain. Thus it is possible to ascertain also the relative weights, or values, people attach to the various instrumental objectives they have in mind when deciding how to make a journey. The value of the demonstration lies in giving travellers the opportunity to assess a real, as opposed to a hypothetical, option, as this give more validity to their stated choices.

(2) If the travelling public would use the bus system as forecast, what would be the differences in costs and benefits to all sectors of the community compared with the use of their cars?

There seems to be little doubt that a combination of an enhanced bus service and the ground level road network would involve significantly less use of real resources for the community as a whole. At a discount rate of 8 per cent the saving of the public transport schemes over the private transport scheme would be as much as one-third of the total discounted cost of that scheme.

The total discounted cost of the private transport scheme would be about £19.3 million, that of the Stevenage scheme £13.5 million and of the London Transport scheme £13.6 million. These producer/operator costs are the most significant item of difference in the measured costs between the private and public transport schemes.
For the Corporation as current landowner there would be no difference in costs.

Coming now to consumer costs: of those that have been measured in money terms, safety and total journey time (consisting of trip and trip-end time), the advantage is again with the public transport schemes, since accident and journey time costs to Stevenage travellers would be lower. The total discounted capital cost of the private transport scheme would be about £30 million, that of the Corporation £27 million, and that of London Transport £29 million.

For those consumer costs which have not been measured in money terms (mode and trip quality for Stevenage travellers, and amenity to current occupiers), the points system explained above, which we used to weight these sectors and their objectives, also showed an advantage to the public transport schemes. On an equal weighting of sectors and a weighting of objectives which considers mode quality to be six times as important as trip quality for Stevenage travellers, with a weighting of sub-objectives for this sector in the following order of increasing importance (flexibility, utilisation of time, healthy exercise, effects on health, personal effort, comfort and status, convenience), the public transport schemes would have a 61 per cent advantage over the private transport scheme. This advantage is decreased as the traveller sectors are weighted more heavily in relation to current occupiers. But, even when Stevenage travellers are weighted globally at twenty times the current occupiers, the advantage still lies with the public transport schemes.

These conclusions apply to those trips that have been quantified for the purposes of the analysis. When background traffic which has not been quantified is brought into consideration the conclusions are reinforced.

All in all, the conclusion from the analysis is that on the assumptions and forecasts made for the community as a whole a combination of an enhanced bus service and the ground level road system is better than building the elevated road works and supplying a reduced or residual bus service.

(3) What prices would need to be charged to bus passengers to make the service financially self-supporting in the sense of balancing revenues and expenditures?

The issues in the pricing of the bus service were brought out in our financial operating analysis, which showed the full financial operating accounts of the transport system (that is, track and car parks and moving vehicles), and also the distribution of this annual cost between the individual public and transport authorities, industrialists and car owners. In brief, all sectors would be in deficit at 1967 prices, but they would have the benefit of a transport system in each case.

The bus fares that would be necessary to cover the costs of, for instance, the London Transport enhanced bus service would be about 3.94p per journey in 1975, falling to 3.21p per journey in 1995. The fall between 1975 and 1995 occurs because, with the growth in population of the town, the percentage increase in the number of journeys is expected to be greater than the percentage increase in costs.

These fares for an enhanced service do not seem high in relation to what Stevenage passengers were in fact paying in 1966. A detailed sample analysis of one of the existing routes in 1966 showed that about half of all adult passengers paid 3.33p per journey leg and a quarter paid 5p or more per journey leg.

The assumption of constant prices at the mid-1967 level, assuming one-man operation for buses with appropriate bonus payments to the driver, is also optimistic.
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for bus costs. In fact wages are likely to rise at a greater rate than average prices, and bus operation is a labour-intensive activity even with one-man operation. Thus costs for public transport are likely to rise relatively to other costs such as private motoring costs.

(4) If this charge were higher than bus passengers could be expected to pay, or so high as to counteract the attractions of the service, would there be the possibility of cross-subsidisation from savings accruing to other sectors of the community from the enhanced bus service?

If it were important for London Transport to cover its costs from the outset, and if it were found that the 2·5p flat fare was the maximum that bus passengers would be prepared to pay without the risk of their diverting to cars, the question would then arise where the bus subsidy would come from. In the study no account was taken of possibilities in the new subsidies for public transport envisaged by the Ministry of Transport (Cmd. 3481). From our financial operating analysis there emerged the other possibility of subsidy from the sectors which stand to make a saving from the introduction of the public transport system, i.e., the Development Corporation and the local authorities through their savings on the cost of the elevated roads, and the industrialists from their savings on capital and running costs of car parks, as compared with the private transport scheme. Loan charges on investment in roads would exceed the amount of the subsidy required at a 2·5p flat fare.

GENERAL APPLICATION OF THE CONCLUSIONS

The general applicability of our conclusions can be seen from our fifth question:

(5) What general conclusions have emerged from this study with a bearing on fuller or lesser motorisation of interest both in Stevenage and elsewhere?

It appears from our study that the community of Stevenage would be better off if, instead of planning for what is generally termed "full motorisation" and a token bus service, it spent its resources on and used a high-quality bus service and a less elaborate road system. Stevenage is a "New Town" and has been planned and built at a time when the motor car is our prime means of transport and when knowledge of the growth of journeys can be anticipated, so that to adapt its existing road system to full motorisation is relatively cheap compared with the cost in towns of a similar size built for the horse and carriage, where major improvements to the road system require expensive demolition of property and greater disruption to people's lives and amenity. (What better example of this, although in a conurbation, than the proposed urban motorway system for London, or the ever-present examples of the Hammer-smith and Chiswick flyovers?)

Our study showed that, of the elements we had been able to measure in money terms, about one-third of the saving of a public transport scheme over the private transport scheme was due to saving on "track" – the primary road system, – and that about 60 per cent of the savings accrued to the producers and operators of the composite transport system and only 40 per cent to the travellers – including 35 per cent due to a saving in trip-end time spent parking the car. If unmeasured elements of cost for travellers and adjoining occupiers were considered equally
important, the greater part of the saving in cost would be found to be in amenity to adjoining occupiers. Mode and trip quality combined (excluding safety and time, which were measured in money terms) were fairly evenly balanced for the schemes, with the edge in favour of private transport. The conclusions turn on these three main variables: the cost of the track, the amount of trip time and the effect on the amenity of adjoining occupiers.

It remains an open question whether this conclusion would hold for towns of greater size where, for the same proportionate shift to public transport, the resulting flows would justify another form of public transport such as the "fixed line haul" grouping mentioned earlier, requiring separate track and routing and therefore greater investment of resources. A public transport system requiring a new track through an established area could prove relatively more expensive on all three counts; the cost of the track might possibly be cheaper than vastly improving the road system, but the disruption to amenity could be greater and, as it would be less flexible in routing, trip-end time could also be greater, although with longer distances between stops total trip time might be less. Thus our general conclusion remains to be tested for these circumstances.

Finally we make three points:

1. A general presumption underlying most of our planning today is that the use of the motor vehicle is so attractive to vehicle owners that, unless there is to be frustration of consumer sovereignty in an important area of life, we must plan for full motorisation. Until recently most transport studies, whilst providing -- at vast expense -- a great deal of useful and vital data on where people are likely to travel to and from, have only paid lip service to this question of how they will travel, generally ending up with recommendations for "fully motorised systems". But our study shows that in terms of total community resources full motorisation would be wasteful as an alternative to less than full motorisation and a high quality bus service, at any rate in a town the size of Stevenage, of eventually 100,000 people. In other words, there is a case for considering public intervention against the unfettered accommodation of individual consumer preference. The purpose of the intervention would be to provide such an attractive bus service that some marginal travellers would prefer to leave their cars at home.

2. Our study also suggests that perhaps the motorist's apparent preference for using his car rather than public transport is not a fully reasoned choice, or one based on full information. As a citizen he is using more real resources for a fully motorised scheme, and as a consumer he is incurring heavier direct and indirect costs. He is exposed to more accidents and, while saving a margin of time when travelling in the motor vehicle, is involved in much heavier consumption of time when trying to park it. And he suffers a degraded environment.

3. But, even were the choice to be left to the motorist, he has not today in many communities a really attractive bus service as a substitute to the motor vehicle. The study showed that such a service is technically possible in Stevenage, and moreover, on the assumptions as to constant prices and levels of traffic that have been made in the study, it is reasonable to expect that the
annual operating costs could be met by travellers. Even if the fares alone were not able to meet the operating expenses over the next ten years or more, there is scope for subsidisation. A high quality public transport system in Stevenage and towns of similar size is thus not financially out of the question.

The open question still remains – would the public use a “super” public transport system if it were to be provided? We hope our study will serve to stimulate further research into the determinants of people’s behaviour in making their journeys, so that this question can be answered.

REFERENCES


*Nathaniel Lichfield and Associates, London*