MANAGEMENT OBJECTIVES, FARES AND SERVICE LEVELS IN BUS TRANSPORT

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1. INTRODUCTION
The aim of this paper is to consider the implications of alternative management objectives for public transport in terms of fares, service levels and financial results. The need for the paper arises because there appears to be a widespread assumption that public transport should—in the absence of any specific reasons for subsidy—be operated "commercially" in some sense (DoE [3]; Tyson [14]). In fact the normal circumstance of public transport operation, that the producer produces output in terms of bus miles while the consumer consumes passenger miles, both complicates the task of the operator—unlike the traditional textbook firm he has to choose both price and output level—and leads not just to doubts about the desirability of normal commercial criteria but also to considerable ambiguity as to what the normal commercial criterion is.
The formal content of the exposition is developed in terms of a grossly simplified model of a bus company. It is assumed that demand in terms of passenger miles \(Q\) is a function of price per passenger mile \(P\) and the number of bus miles operated \(B\); that is:
\[
Q = f(P, B) \tag{1}
\]
Bus mileage operated influences demand because a larger bus mileage implies a denser and/or more frequent network of services. This reduces passenger walking and waiting times, increases the range of trip destinations available, and increases the probability of being able to arrive at the destination at the preferred time.
It may be argued that the bus mileage operated also imposes an upper constraint on the number of passenger miles that can be carried, given the capacity of the type of bus operated. However, this constraint is seldom in practice the determining

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*Institute for Transport Studies, University of Leeds. I wish to express my gratitude to colleagues at Leeds University, especially P. J. Mackie, to Dr. J. D. C. A. Frideaux of British Rail and to J. Maw of London Transport, who have discussed this topic with me. Responsibility for the end product is solely my own.

1What follows is cast solely in terms of a bus operator for ease of exposition. Bus operation involves a relatively homogenous output and there is evidence that economies of scale with respect to fleet size are exhausted at a relatively low level [7]. This at once reduces the number of problems to be dealt with.
factor. Since the extra costs of operating a large vehicle rather than a small one are normally small, the same vehicles are used both in the peak and in the off-peak. The result is low off-peak load factors, so that ample capacity is offered on the route as a whole; but, during the (usually short) peak, demand may exceed the capacity of the first bus to come along. What determines service frequency, then, both in the peak and in the off-peak, is the quality of service the operator seeks to give. In the peak, however, this quality of service aspect is reflected in the length of the wait for a bus that has room to spare, rather than merely for the next bus. For simplicity, we treat the two aspects of quality symmetrically. In the formal model we also ignore problems of aggregation, including varying fares per mile, distance tapers, season tickets, etc. These will be discussed in the text, however.

The cost function used will assume a constant utilisation per bus and make total cost \((C)\) proportional to bus miles operated \((B)\):

\[
C = cB
\]

(II)

Again, differences between routes and the problem of the peak are ignored, but these may easily be taken into account by distinguishing between a number of categories of bus miles. Example are given in Section 4.

The effect of this is to make the relationship between costs and traffic carried indirect. A number of criticisms may be made of this. In the first place, it may be argued that, while in the short run excess capacity is common, in the long run costs depend more directly on traffic. To argue thus is to misunderstand the main point we are making, which is that there may be good reason to provide a higher frequency than is necessary simply to shift the volume of traffic even in the long run. A second criticism is that we are ignoring the cost savings that would result from the possibility of operating smaller vehicles if traffic were less dense. This is a valid point, but these cost savings would probably not be large enough to affect the results significantly. Indeed, it is this economy of scale in vehicle size that is at the heart of the current argument.

2. ALTERNATIVE OBJECTIVES FOR NATIONALISED INDUSTRIES

Traditionally, the choice of objectives for nationalised industries has usually been regarded as being between purely commercial criteria and marginal cost pricing (with its companion criteria for investment and non-marginal adjustments—in full, social surplus maximisation). In this section we consider the implications of following either of these objectives, assuming the commercial criterion to be that of profit maximisation.

2.1 Profit maximisation

The implications of profit maximisation in these circumstances are obvious:

\[
\text{Max } z_t = P f (P, B) - cB
\]

First order conditions are:
\[
\frac{\partial z_1}{\partial P} = \frac{\partial [P \cdot f(P, B)]}{\partial P} = 0
\]
\[
\frac{\partial z_1}{\partial B} = \frac{\partial [P \cdot f(P, B)]}{\partial B} - c = 0
\]

That is, price at each period is lowered until the marginal revenue equals zero (note that the marginal cost of carrying one extra passenger, given spare capacity, is zero), while extra passenger miles are run as long as they bring in more extra revenue than they cost. It should be noted that the relevant consideration here is not the revenue paid by the actual users of the extra bus miles as revealed by ticket sales. It is only that part of the revenue which would be lost if those bus miles were not operated.

It will be seen in the numerical example (Section 4) that this objective leads to a higher peak price than off-peak price, simply because—at any given price—the peak elasticity of demand is assumed to be less than the off-peak. To the extent that it is possible to discriminate between passengers on grounds other than time of day (e.g. by route or journey distance) the fare per mile will also be set to maximise revenue. Thus, if—at any given price—the elasticity of demand for long journeys is greater than that for short journeys, this would justify a fare scale tapering with distance.

In this paper we assume the existence of a single operator with an area monopoly. Few economists have ever suggested that for a monopolist to maximise his profits is in the public interest. If "operating commercially" is not to be taken to mean maximising profits, what does it mean? An alternative is to operate only that quality of service which at least covers its costs. However, what pattern of services will cover its costs depends on the prices charged. Since the operator is free to determine both service quality and price, a requirement to break even merely imposes a constraint on the combinations of prices and qualities he can consider. An objective function is still required to choose between points in this set.

An example may be worth while here. For simplicity, assume that the demand function takes constant elasticity form and that there is no need to differentiate by time of day.

\[ Q = \alpha P^\beta B^\gamma \]

The constraint imposed by the requirement to break even is then:

\[ \alpha P^{\beta+1} B^\gamma - cB = 0 \]

By implicit differentiation the slope is as follows:

\[ \frac{dP}{dB} = \frac{(\gamma P - c)}{(\beta + 1)cB} \]

It is reasonable to assume that the fare per passenger mile is less than the cost per bus mile \((P < c)\); that the elasticity of demand with respect to mileage run \((\gamma)\) lies between 0 and 1, and that the elasticity of demand with respect to fares \((\beta)\) lies between 0 and -1. Therefore \(\frac{dP}{dB} > 0\), and we have a locus of points such as is given in Figure 1.

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FIGURE 1

_An Example of the relationship between breakeven bus miles and fare._
In this example, we took $\alpha = 1$, $\beta = 0.4$, $\gamma = 0.7$ and $\epsilon = 50$. Figure 1 shows the implications for breakeven bus mileage of increasing bus fares in 1p steps from 1p to 10p. Obviously, in practice, it would be dangerous to assume that the relevant elasticities could be treated as constants over such a wide range.

Outside the range of current experience, the schedule may become negatively sloped or it may be impossible to break even at any price. But within the range of most current operations, the choice is either low service quality and low price or high service quality and high price (Webster [15]).

2.2 Maximisation of a Pareto-type social welfare function

The conventional alternative to profit maximisation is social surplus maximisation.

Under the usual assumptions (Turvey [12]), and for convenience inverting the demand curve to give $P = f^{-1}(Q, B)$, this objective may be written

$$\text{Max } z_2 = \int_0^Q f^{-1}(q, B) \, dq - cB$$

First order conditions are:

$$\frac{\partial z_2}{\partial Q} = f^{-1}(Q, B) = 0$$

$$\frac{\partial z_2}{\partial B} = \frac{\partial}{\partial B} \left[ \int_0^Q f^{-1}(q, B) \, dq \right] - \epsilon = 0$$

In other words, a zero fare is charged (or, if this leads to the capacity constraint becoming binding, whatever fare is needed to take up exactly the capacity supplied), and bus mileage is expanded as long as the extra consumers' surplus from doing so exceeds the cost. Almost certainly, the implementation of this approach would involve subsidy.

However, two important factors have been ignored. The first is that public funds are likely to carry a shadow price greater than unity. The second is that externalities are imposed by one passenger or another (Mohring [8], Mohring and Turvey [9]). When an individual bus is full, even if there is spare capacity overall, the passengers riding on it are imposing a cost on other intending passengers in terms of the waiting time until the next bus with spare capacity comes along. If any of them value their bus trip at less than that cost, then, according to the above social welfare function, they should be priced off the bus. In addition, extra passengers may prolong both the number and length of stops the bus makes, again delaying other passengers (strictly, this should also be introduced into the bus operator's cost function). Thus a case exists for a fixed boarding charge plus a variable charge over those stretches of route for which the bus is full. (Whether it is worth implementing depends on the costs, both administrative and in terms of delay, of fare collection.) However, it would obviously only be by the most extraordinary accident that revenue exactly covered the bus operator's costs.
3. THREE ALTERNATIVE "COMMERCIAL" CRITERIA

Contemplation of the previous two solutions to price and output policies has not resolved the issue of choosing an appropriate policy. In the circumstances of most bus operators, profit maximisation amounts to monopolistic exploitation; and the maximisation of a Pareto-type social welfare function leads to prices not being based on the operator's costs and (probably) to a deficit. Calls to implement the latter policy would undoubtedly meet with the response that it could only be done if other socially worthwhile projects in other areas of public spending were sacrificed (that is, public funds have an opportunity cost greater than one). In this case, it seems sensible to make maximisation of all future objectives examined subject to a budget constraint. This is expressed as a target deficit \(D\), but \(D\) may obviously be positive, zero or negative (a profit target). The desirable size of \(D\) can only be determined with reference to the other sources and uses of funds open to the financing authority. Our first realistic alternative, then, becomes objective 2 above rewritten with a budget constraint.

3.1 Maximisation of a Pareto-type social welfare function subject to a budget constraint

\[
\text{Max } z_3 = \int f^{-1}(q, B) dq - cB - \lambda_3 \left[ cB - Qf^{-1}(Q, B) - D \right]
\]

First order conditions are:

\[
\frac{\partial z_3}{\partial Q} = f^{-1}(Q, B) + \lambda_3 \frac{\partial [Qf^{-1}(Q, B)]}{\partial Q} = 0
\]

\[
\frac{\partial z_3}{\partial B} = \frac{\partial}{\partial B} \left[ \int f^{-1}(q, B) dq \right] - c + \lambda_3 \left[ \frac{\partial [Qf^{-1}(Q, B)]}{\partial B} \right] = 0
\]

Note that \(\lambda_3 = \frac{\partial z_3}{\partial D}\) i.e. \(\lambda_3\) is the shadow price of public funds in terms of social surplus. Thus the two marginal conditions may be worded:

- Reduce price as long as price exceeds the revenue lost by the reduction necessary to attract one extra unit of traffic multiplied by the shadow price of public funds.

- Increase bus mileage as long as the extra social surplus generated exceeds the reduction in profit (= increase in loss) multiplied by the shadow price of public funds.

A full analysis of price would obviously again include such inter-passenger externalities as were mentioned in section 2 above.

As a theoretical basis for public transport operation, this approach appears to be very attractive. Organisation could proceed by the financing agency either passing to the operator the current value of the shadow price, \(\lambda_0\), or more likely (given the difficulty in calculating \(\lambda\) and the need to have budgetary control of public spending) by an iterative procedure in which a given budget constraint \(D\) is defined, its implications worked out, and subsequently it is raised or lowered according to how the marginal benefits of public transport subsidy compare with those of other sectors. In such an analysis other factors, such as externalities,
distributive effects and diversion of traffic to and from other modes, would also obviously need to be taken into account.

Ignoring factors such as delays imposed by one passenger on another, this objective does not appear too complicated to administer. Approximating the demand function by a constant elasticity form, the first condition becomes (writing \( e \) for the price elasticity of demand):

\[
P + \lambda_3 P(1 + 1/e) = 0
\]

or \( 1 + 1/e = 1/\lambda_3 \)

If there were the possibility of discriminating by route, time of day or length of journey, then—for a given level of bus mileage—fares would always be set so that elasticities of demand were equal (as long as \( e > -1 \). If no solution exists with \( e > -1 \), the constraint cannot be met). The formula may be extended to include cross-price elasticities if significant.

It will be noted that this is a special case of the Baumol-Bradford finding \[2\] that prices should be set so that

\[
\frac{P_1 - MC_1}{P_1} = \frac{P_2 - MC_2}{P_2} = \frac{1}{\varepsilon_1} = \frac{1}{\varepsilon_2}
\]

If \( MC_1 = MC_2 = 0 \), this reduces to:

\[
\frac{1}{\varepsilon_1} = \frac{1}{\varepsilon_2}
\]

Decisions on the level of bus mileage to operate will be based on a cost-benefit assessment. An expansion will go ahead if the total benefit to new and existing users, less the cost, exceeds \( \lambda_4 \) times the net loss of profitability resulting. These benefits can be measured using standard cost-benefit techniques based on the resulting reduction in generalised cost.\(^8\) Distributional weightings may also be introduced into pricing and investment decisions if desired.

3.2 Maximisation of passenger mileage subject to a budget constraint

There appears to be no great theoretical difficulty in introducing the objective considered above. However, the objection may still be voiced that the approach is too complicated to command widespread understanding and support. Such considerations have led to the adoption by London Transport of a simpler rule—maximisation of passenger mileage subject to a budget constraint.

\[
\text{Max } z_4 = f(P, B) - \lambda_4 [cB - P . f(P, B) - D]
\]

First order conditions are:

\[
\frac{\partial z_4}{\partial P} = f_P + \lambda_4 \left[ P . f(P, B) \right] = 0
\]

\[
\frac{\partial z_4}{\partial B} = f_B + \lambda_4 \left[ f(P, B) - c \right] = 0
\]

\(^8\)But how to treat service frequency in calculating generalised cost is itself a source of considerable uncertainty \[1\].

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Note that the shadow price of public funds, \( \lambda_i \), is now expressed in terms of passenger mileage. The marginal conditions now read:

Reduce price as long as the increase in passenger mileage resulting exceeds the loss of revenue multiplied by the shadow price of public funds.

Increase bus mileage as long as the increase in passenger mileage resulting is greater than the net addition to the financial loss multiplied by the shadow price of public funds.

London Transport in fact applies these rules in exactly the iterative fashion described above. Given the financial target, the shadow price of public funds in terms of passenger mileage is estimated and used as a basis for interim decision-taking. As the financial results of adopting this shadow price become clearer, the shadow price is adjusted up and down as required.

It should be noted that an alternative way of operating this criterion would be to calculate the shadow price, \( \lambda_i \), and then to tell operators to maximise profits subject to receiving a subsidy of \( \frac{1}{\lambda_i} \) per passenger mile carried. For, given a subsidy of \( s \), this would lead to:

\[
\text{Max } Z_s = (P + s)f(P, B) - cB
\]

First order conditions are:

\[
\frac{\partial Z_s}{\partial P} = (P + s)f_P + f(P, B) = 0
\]

\[
\frac{\partial Z_s}{\partial B} = (P + s)f_B - c = 0
\]

Rearranging the marginal conditions gives:

\[
sf_P + \frac{\partial[Pf(P, B)]}{\partial P} = 0
\]

\[
sf_B + \left[ \frac{\partial Pf(P, B)}{\partial B} - c \right] = 0
\]

If \( s \) is set equal to \( 1/\lambda_i \), these conditions are the same as those derived above.

How does this differ from the previous objective? Social benefits of public transport must be related to passenger mileage in some way. However, it is easily seen that the two objectives imply different combinations of price and passenger mileage. For instance, suppose that increases in bus mileage benefitted existing users but generated no new custom. Maximisation of passenger mileage would then lead to a minimum quality of service with low fares; a full social surplus calculation might justify higher fares but a better service.

The shortcomings of this objective are only fully seen when thus applied to a collection of services. In practice, bus miles and passenger miles are not homogenous, and the social benefits derived from them vary with time and place. A better approach might be to calculate a range of shadow prices appropriate to various situations. To some extent this would detract from the simplicity that is the main attraction of this approach.
3.3 Maximisation of bus mileage subject to a budget constraint

\[ \text{Max } z_s = B - \lambda_s [cB - P \cdot f(P, B) - D] \]

First order conditions are:

\[ \frac{\partial z_s}{\partial B} = 1 + \lambda_s \left[ \frac{\partial f(P, B)}{\partial B} - c \right] = 0 \]

\[ \frac{\partial z_s}{\partial P} = + \lambda_s \frac{\partial f(P, B)}{\partial P} = 0 \]

The shadow price of public funds, \( \lambda_s \), is now measured in terms of bus miles. The result is that price is raised to its revenue-maximising position. Bus mileage is expanded as long as the resulting increase in the loss multiplied by the shadow price of public funds is less than the increase in bus mileage itself. When it is cheaper to put on extra bus mileage on certain routes or at certain times of day than others, this will lead to a divergence between policies for bus mileage maximisation and revenue maximisation (see Section 4). This alternative may lead to at least as high a price as any of those put forward above. In comparison with profit maximisation, the first marginal condition for the setting of price is identical, but the fact that a higher quality service in terms of bus mileage is put on in this case may mean that the slope of the demand curve is different, and therefore that the condition implies a different price.

It is also worth noting that this objective is equivalent to profit maximisation with a subsidy per bus mile of \( \frac{1}{\lambda_s} \). If fuel tax is regarded as being deliberately designed to conserve energy or limit the use of road space, and therefore to be regarded as part of the marginal social cost of use of fuel, then fuel tax rebate is just such a subsidy. (If fuel tax is, on the other hand, merely a convenient way of raising revenue, its rebate is not in terms of social cost a subsidy at all.)

4. A NUMERICAL EXAMPLE

For illustrative purposes, a specific numerical example is introduced. A good deal of effort has been put into attempting to estimate the elasticity of \( Q \) with respect to \( P \) and \( B \) in recent years. Plausible values would seem to be \(-0.5\) and \(0.7\) in the off-peak period and \(-0.25\) and \(0.3\) in the peak [10], [4]. However, it would be inappropriate to assume a constant elasticity demand function for our present purposes. This is because, with these elasticities, a rise in price would always produce an increase in revenue, while (with constant returns to scale) a reduction in bus mileage would always cause a smaller proportionate reduction in revenue than in costs. If this is really true, the problems of bus operators may not be as great as is commonly thought! But it seems more realistic to assume that, beyond a certain rise in price, demand becomes elastic, and similarly for a certain reduction in bus mileage. A functional form which reflects these assumptions is the semilog form:

\[ \log Q = a - bP - c \frac{1}{B} \]

This yields elasticities of:
\[ P \frac{\partial \log Q}{\partial P} = -bP \]
\[ B \frac{\partial \log Q}{\partial B} = \frac{C}{B} \]

Note that each elasticity is assumed independent of the value of the other variable. This is convenient, but may be unrealistic in practice.

One set of values of the parameters which give the above mentioned elasticities at \( P = 5 \) (in pence per mile) and \( B = 1 \) (in hundred miles per day) are as follows (writing subscripts \( P \) and \( O \) for peak and off-peak respectively):

\[
\log Q_P = 4 - 0.05P_P - 0.3/B_P
\]
\[
\log Q_O = 4 - 0.1P_O - 0.7/B_O
\]

These equations are used subsequently in numerical illustrations. Cross-price effects between peak and off-peak are ignored.

The cost function used will assume a constant utilisation of buses used on peak only and day-long services, and constant returns to scale. Costs will therefore depend solely on bus miles operated in the peak and in the off-peak. Plausible parameters (in pounds per hundred miles) would seem to be [11]:

\[ C = 80B_P + 20B_O \]

As a second example, results are reported for the set of equations:

\[
\log Q_P = 4 - 0.04P_P - 0.3/B_P
\]
\[
\log Q_O = 4 - 0.12P_O - 0.5/B_O
\]
\[ C = 60B_P + 40B_O \]

This example might be interpreted as comprising two routes, one of which (route P) is most heavily used for the journey to work, and the other (route O) having a higher proportion of leisure travel. Of course, differences in costs and demand elasticities between routes may occur for many reasons other than journey purpose, including differences in service speed, population density, income and car ownership levels. A full optimisation on a route-by-route basis would need to take these into account.

The implications of following each of the suggested objectives in this numerical example were computed by an iterative nonlinear optimisation programme, and are set out in Table 1. Net social benefit is measured as:

\[ NSB = \int_0^{Q_P} \int_0^{Q_O} (B_P, Q_P) dQ_P + \int_0^{Q_O} (B_O, Q_O) dQ_O - C \]

where \( \int_0^{Q_P} \) and \( \int_0^{Q_O} \) are the inverses of the demand functions specified above. Since

\[ \int_0^{Q} (B, Q) dQ = \left[ \frac{a}{b} - \frac{e}{bB} \right] Q^1 - \frac{1}{b} \left[ Q^1 \log Q^1 - Q^1 \right] \]
Performing the inversion and integration, for case 1:

\[
NSB = (80 - 6/B_P) Q_P^1 - 20(Q_P \log Q_P - Q_P) \\
+ (40 - 7/B_0) Q_0^1 - 10(Q_0 \log Q_0 - Q_0) \\
- 80 B_P - 20 B_0
\]

While the results may depend on the rather arbitrary assumption on functional form, nevertheless some interesting suggestions have arisen from these examples. Firstly, revenue and bus mileage maximisation subject to a budget constraint leads to an expansion of bus mileage far beyond that justified in terms of net social benefits (bus mileage maximisation expands off-peak mileage relative to peak compared with revenue maximisation, which places greater weight on the extra revenue brought in by an expansion of peak bus mileage). This is important, since the natural inclination in a declining industry may be to try to preserve levels of
output and employment at the expense of high fares; moreover, it appears that the traffic commissioners have tended to influence operators in this direction [6].

Unconstrained social welfare maximisation involves zero fares (but it should be remembered that this is ignoring capacity constraints and the externalities imposed by one passenger on another). By comparison, constrained social welfare maximisation implies a higher peak than off-peak fare, and some reduction both in bus mileage figures and in net social benefits. Constrained passenger mileage maximisation implies a lower off-peak fare and higher off-peak service level than social welfare maximisation (which places a higher weight on extra passenger miles when demand is inelastic), but the result is much closer to that of social welfare maximisation than for any other alternative considered.

It is often suggested that cross-subsidisation should not occur between individual routes (e.g. Gwilliam and Mackie [5], p. 572) or between times of day (Travers Morgan [12]). Tables 3 and 4 calculate financial results separately for O and P for
the two examples. (In this calculation, it is assumed that the cost functions given above hold for all possible values of \( B_0 \) and \( B_F \); in practice, the presence of joint costs makes it unlikely that the form given is appropriate for more than marginal adjustments). It is seen that cross-subsidisation between routes and times of day may occur with any of these alternative objectives.

5. EXTERNALITIES

So far in this paper we have said nothing about the social service obligations of bus operators, nor have we discussed the most commonly cited reasons for subsidising public transport—to relieve traffic congestion and to protect the environment by diverting trips from private transport. This is because we have been concerned to clarify the results of applying conventional economic analysis to public transport in a partial equilibrium framework.

There is no guarantee that pursuit of the above objectives will fulfil the often espoused basic requirement of a public transport system, that of providing a basic service to fulfil the needs of those who do not have access to a private car. Any of these objectives may lead to the provision of high quality public transport in certain areas, while other areas of sparse population or high car ownership are deprived of all public transport. Thus it is clear that any realistic view of management objectives in public transport would need to take account of many more constraints on the routes operated, on the level of accessibility provided from different areas to work places, schools, shops and hospitals. Where such constraints are imposed it is often believed to be more appropriate to pay a direct grant related to the cost of providing the service in question, rather than to provide blanket revenue support to the operator. Then, it is argued, the cost of this non-commercial operation will be readily apparent to decision-takers and the public at large.

A number of problems become apparent, however. Firstly, the issue is complicated by the finding that, even in the absence of specific obligations of this kind, an efficient operator is likely to provide certain services with a financial loss. Clearly, the cost of the obligation then becomes the additional deficit resulting (this may be less than or greater than the financial loss on the service in question). Secondly, the costs of such obligations are not independent. Suppose that, for social reasons, a certain set of routes is to serve more points and/or operate higher frequencies than would otherwise be the case. The cost of achieving any one of these improvements will depend on the level of service currently being offered to other points in the system. Disaggregation to the level of the individual service improvement may be achieved in any of a number of ways. Where such interdependencies exist, it may be worthless to try to achieve disaggregation of financial support below the level of a group of services, or perhaps even the undertaking as a whole. This is more likely to be the case in urban areas than on inter-urban and rural services. (Needless to say, this in no way precludes evaluation of specific packages of service changes to see what they would cost.)

The problem of the externalities produced by any traffic diverted to private transport is rather more complicated. Clearly, public transport subsidy is just one of many policies which can be used in this connection—alternatives include traffic
management, parking charges and restraint, new road-building, influencing the location of homes and workplaces, altering the technical characteristics of the private car with respect to size, performance and pollution, etc. The best package of such policies for any particular case can only emerge from a detailed study and evaluation of alternatives.

Subject to this caveat about the need to consider first other policy instruments for achieving the same end, one may ask the question what social benefits are omitted from the above consideration of the determination of fares and service levels. The answer, in money terms, is clearly the difference between marginal social cost and marginal benefit of car use multiplied by the proportion of additional public transport traffic that is attracted from car (if the objective of the undertaking is stated in units other than money, e.g. passenger miles, this may then be converted at the appropriate shadow price).

Now there are two main problems with making this operational. The first is measurement. This is particularly a problem with the environmental costs of road traffic. The second is implementation, given that all the elements involved will clearly vary greatly with time and place. In other words, it is impossible to deal adequately with this factor in terms of a single shadow price to be added to the benefit resulting from all public transport trips. (If this were the best that could be done in practice, however, the usual rule of adopting an average weighted by the slopes of the relevant cross-price demand schedules would apply.) One returns to the need to adopt a set of shadow prices categorised by area and by time of day.

An example may help. Suppose that a certain operator were following a policy of maximising passenger miles subject to a budget constraint, and that the current shadow price of a passenger mile were 2p. Suppose also that for particular circumstances the marginal social cost of car travel exceeded its private cost by 20p and that the proportion of the additional traffic attracted that diverts from car is 0.1. The result would be to impute an extra benefit worth 1 passenger mile to each passenger mile attracted in these circumstances (i.e. to give passenger miles a weight of 2). Suppose that when service levels are improved the proportion of extra traffic diverted from car is 0.2. The extra benefit imputed to traffic attracted by service improvements would have a value of 2 passenger miles (i.e. these passenger miles would receive a weight of 3).

6. CONCLUSION

The two most commonly advocated objectives for public transport operators are to act commercially, and to seek to maximise a Pareto-type social welfare function. However, the former would, in the absence of competition, encourage monopolistic exploitation, while the latter would involve subsidy and break the direct link between costs, prices and output. In practice, it could probably only be followed subject to a budget constraint. Of the two alternative simpler objectives, passenger mileage and bus mileage maximisation subject to a budget constraint, passenger mileage maximisation seemed preferable, although operators themselves may be attracted by bus mileage maximisation, particularly where services are declining.
January 1978

JOURNAL OF TRANSPORT ECONOMICS AND POLICY

Acceptance of the arguments put forward in this paper has some important implications. In the first place, we have argued that—even in the absence of arguments concerning externalities and economies of scale, 2 subsidies to public transport may well be justified, and that their level will be restricted more by the practical presence of a public sector budget constraint than by theoretical considerations concerning the Pareto-optimal allocation of resources.

In the second place, given the presence of a budget constraint, pursuit of any of our three realistic objectives is likely to involve cross-subsidisation between routes and between times of day, even in a situation in which the operator is required to break even overall.

However, excessive cross-subsidisation clearly has dangers. Maximising profits on a profitable service in order to subsidise unprofitable ones may well involve a severe loss of social benefit on the former.

Thirdly, given this situation, additional motives for subsidy for social reasons or concerned with the external costs of private transport may be incorporated into the decision-taking process as constraints or as shadow prices. Given the interdependence between the costs of such departures from the simple situation outlined earlier in the paper, it seems doubtful whether it would be worth while to try to give specific subsidies for these, at any rate in urban areas.

Finally, reference must be made to one important variable which we have so far ignored—the internal efficiency of the operator. Our view is that, given the inevitable degree of monopoly power in public passenger transport, even the most “commercial” of objectives will not necessarily prevent internal inefficiency. But the application of any system of clear objectives and financial constraints will serve to reduce that risk. It is open-ended deficit finance and the lack of objectives by which performance may be judged, not the presence of public transport subsidy as such, that leads in our view to the risk of diminished pressure for efficient operation.

REFERENCES

2At any rate in the way in which these are usually regarded. In fact, the arguments put forward in this paper do rest on the presence of economies of scale in terms of vehicle size. If it were not for this, public transport operators could offer each individual passenger a separate individually-tailored service!
MANAGEMENT OBJECTIVES IN BUS TRANSPORT

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