COMPETITION BETWEEN MINIBUSES AND REGULAR BUS SERVICES

By P. H. Bly and R. H. Oldfield*

INTRODUCTION

A private consortium, Associated Minibus Operators Ltd. (AMOS), has recently applied to run bus services across Central London, using 16-seater minibuses, along routes which would be in part in direct competition with existing London Transport\(^1\) services. Extensive minibus services are operated successfully in many large cities of the Third World, but they play a very small, and largely rural, part in Western industrialised countries. Drivers' wages are high in developed countries, and form a large part (typically 40 per cent) of bus operating costs; therefore, unless average occupancies are low all day, it is cheaper to use big buses. Small buses are likely to be more expensive to operate for a given capacity; but there will be more of them and the service frequency will be higher, to the benefit of the passengers. Moreover, it has been suggested that if the small buses were operated by owner/drivers, or by consortia of operators owning a few buses each, the organisation, operation and labour constraints would be more flexible than with existing large operators, so that costs could be reduced. For these reasons Walters (1979), among others, has argued that minibus services do have a role to play in Western cities. More recently, Glaister (1985) has constructed a computer simulation model of small buses operating in competition with large buses; this suggests that minibus services could be profitable, even if they ran at low occupancies and high fares, because travellers with relatively high values of travel time would be willing to pay for their higher operating speed.

The question whether large double-deck buses are the best solution to public transport services on London roads has been tackled previously by Webster (1968) and Webster and Oldfield (1972). They used a highly aggregated approach,

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\(^1\) The term 'London Transport' will be used throughout this paper to refer to the existing operator, even though London bus services are now operated by London Regional Transport. The study refers to 1981, when the operator was London Transport Executive.
in which travel by all modes was represented by an average journey, and the interaction between the flows of different road vehicles and the speeds at which they could travel was considered in terms of a single “representative” road link. Both these studies concluded that the optimum bus size for services in Central London was perhaps slightly smaller than the size currently in use; but, in view of the use of averages in the modelling and the necessarily rather sweeping assumptions made, the difference between the model predictions and London Transport’s actual operating strategy is of no practical significance. The models did show quite clearly, however, that the use of much smaller buses was unlikely to be beneficial, not merely because of their relatively high operating cost per seat-kilometre, but also because they would have to be operated in very large numbers to provide adequate capacity, and this would severely aggravate the existing traffic congestion.

These predictions have been updated in the work described here, but the results remain much the same. Greater interest attaches to an extension of the modelling to represent competition between London Transport’s existing stage bus services in central London, on the one hand, and bus services provided by a network of routes using smaller buses, down to 10-seater minibuses, on the other.

The modelling of this situation causes additional problems quite apart from those inherent in modal choice modelling. Traditional modelling treats each available mode as a separate entity, and each takes a share of the market in some type of inverse proportion to the “generalised cost” (that is, time plus money) of a journey by that mode. These generalised costs can be calculated from the average journey components for each mode, and the implication of this approach to modal split is that the traveller decides which mode is best before he sets out. The modal split mechanism generally used tends not to differentiate very sharply between the costs of alternative modes (that is to say, even if one mode is quite a bit more expensive than a competing mode, in terms of generalised cost, an appreciable proportion of travellers may still elect to use it), because the calculation is based on averages and cannot allow properly for the wide variation in travellers’ situations and preferences. This type of modal split modelling may still be appropriate in circumstances where there is physically separate access to services operated by large buses and by small buses (for example, if the services operate along different roads), so that the traveller must decide which he is going to use before he begins his journey. Even so, it seems likely that the modal choice will be relatively sharp, because the two types of services will probably be seen as very similar in nature if we assume, as these calculations do, that the small bus services are still along fixed routes. If the small-bus services are responsive to demand, travellers may see them as being more closely aligned with taxis, and this type of difference in attributes between the two services would be likely to produce a broader spectrum of perceived generalised costs.

However, minibus services, or at least some parts of them, are likely to be operated along the same routes as the regular London Transport bus services. The stopping places may well be separated, but in practice it will be possible for many passengers to catch either type of bus, and their choice will clearly depend largely on which type of bus is the first to arrive. Thus the decision point is shifted away from the start of the journey to the point of access to the service. A traveller who
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has decided to use a bus will obviously take the first suitable bus to arrive if it is of the preferred type. If it is not, he must decide whether to take it anyway, on the "bird in the hand" principle, or whether to wait for a bus of the preferred type, after giving due consideration to the uncertainty of its time of arrival.

Consequently, the work described here considered two different modelling approaches:

(i) Simple modal choice, appropriate to the situation where the two types of services are physically separate.

(ii) Modal choice at the route: the traveller compares the generalised cost of his journey by the bus which has arrived with that by the other type of bus, taking into account the extra time he would expect to wait for it.

The modelling considers what is likely to happen if the minibus services compete with the existing London Transport services and fares, and also the situation where, in order to compensate for the lost revenue, the LT services are reduced. In practice, of course, an existing operator may make a more specific response to competition, perhaps by offering new types of service altogether, but the two assumptions tested here are the obvious ones appropriate to a general examination of the success or otherwise of competition. Minibus services are assumed to break even financially, if they can exist at all, and we also calculate the net community benefit associated with the introduction of minibus services.

COSTS OF BUS OPERATION

Other things being equal, reducing the size of a bus reduces its operating cost much less sharply than the number of its seats. Thus, the cost per seat-km operated increases as the size is reduced. This is a considerable disadvantage, not easily offset by the higher level of service which can be operated. If the small buses are to operate at fares low enough to attract clientele, their operating costs are a crucial element in the equation.

The assumptions about costing can be separated into three elements: vehicle operating costs (including standing costs), staff wages, and the additional costs of providing peaks in service. The obvious approach is to use the vehicle operating costs published by the journal Commercial Motor (1982) for a wide range of bus sizes, and to marry these with crew costs taken from London Transport’s Annual Reports. These costs have been used in some of the modelling work. But much of the debate about the comparative advantages of small and large buses has centred round the assertion that small buses can be operated more cheaply than figures taken from present bus and coach operations would suggest, because crewing, maintenance and administration can be done more flexibly than is allowed by the constraints of a large undertaking. These arguments tend to confuse the issue between the relative cost advantages of small and large buses, on the one hand, and the comparative institutional constraints of the large public operator and the private entrepreneur, on the other. It seems likely that an operator who is able to run small buses at less cost would also be able to run large buses at less cost.
Nevertheless, because small buses, with their smaller capital cost, are more appropriate to an owner/driver or franchise operator, the calculations presented here also consider the possibility that small buses might be operated more cheaply than the Commercial Motor figures indicate.

The costs of operating light goods vehicles (Commercial Motor, 1982) are shown as roughly half of those for a bus of equivalent size in the 10 to 30 seater range. Given the extra complexity of a bus body compared with a van body, and the more stringent maintenance which would presumably be required of a public service vehicle, the costs of light goods vehicles are plainly an unrealistically low estimate of the minimum costs for operating buses, but they will be used to set a rather extreme lower limit. Thus, for a “Low” cost assumption, operating costs will be taken to be half the Commercial Motor operating costs for a 20-seater bus, and scaled linearly to be equal to the Commercial Motor figures at a bus size of 70 seats. In contrast, the Commercial Motor costs for existing bus operations will be labelled the “High” cost assumption. All the calculations are based on the conditions, services and subsidy prevailing in 1981. In the High cost assumption, crew costs are taken to be those of LT operations in 1981. Including pensions and national insurance contributions, these average £175 per crew member per week. The costings used here differentiate between peak and off-peak services, and allow for the additional costs of crewing the peaks in service; the details of the calculations are given in Oldfield and Bly (1985). These crew costs refer to the prevailing 50/50 mix of one-person-operation (OPO) and driver/conductor operation; drivers’ wages in OPO are generally higher than for two-man working, and it is assumed here that if the LT services were converted wholly to OPO the average cost per driver would rise to about £200 per week. Competition between operators may well reduce the wages which are paid, so in the ‘Low’ cost assumption wages per driver (in a fully OPO system, since the small buses would certainly be OPO) are taken to be £150 per week, including pension and NHI contributions: this is commensurate with the average industrial wage in 1981. The cost is applied to buses of all size. It is convenient to choose a ‘Middle’ cost assumption midway between the High and Low levels, but the reader is warned against the temptation to regard this middle assumption as being the most plausible. High costs are in fact the existing average costs; and though the Low costs have been set as a rather extreme lower limit (and the vehicle operating cost component, in particular, is probably unrealistically low), it is worth noting that the AMOS proposal to run 16-seater buses in London estimated overall costs at about 30 pence/km (Hewing, 1983, and White, 1983), excluding the profit to be taken by the Associate owners of the buses, and this is well below the Low cost assumption. However, both Hewing and White criticise the AMOS costings as being grossly underestimated. Hewing gives LT’s own estimates for operating the AMOS proposal: these are equivalent to an average of 52 pence/km, and it is interesting that this is close to the Middle cost assumption, and markedly less than the High (that is, existing average) costs. Certainly, it seems likely that competition would produce some reduction in current operating costs, but by how much is very uncertain, and the reduction might well apply to large buses to much the same degree as to small buses.

Figure 1(a) summarises these cost assumptions in terms of average cost per
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Cost Assumptions:

- ‘High’ — Commercial Motor operating costs, driver costs at £200 per week.
- ‘Middle’ — 20-seater bus at 75% of Commercial Motor operating costs, scaling up to 100% at 70-seater; driver costs at £175 per week.
- ‘Low’ — 20-seater bus at 50% of Commercial Motor operating costs, scaling up to 100% at 70-seater; driver costs at £150 per week.

FIGURE 1

Operating costs assumed for buses of different size, illustrated by (a) the average occupancy required to cover costs if passengers were charged the same fares as on LT buses, and (b) the cost per seat-km provided.
vehicle-km, and shows what the average occupancy would have to be to cover costs if passengers were charged at the 1981 London Transport fare level of 5.1 pence per kilometre. Of course, this fare is subsidised, but it would be the level against which small buses would have to compete under "present" (that is, 1981) conditions. As it happens, however, calculation of costs for a flat all-day service, without peaks, which is the basis for the costings in Figure 1, shows that this fare is also the break-even fare for 70-seater buses operating at about LT's present average occupancy. With High costs the 10-seater would be over full; but of course the smaller buses could charge higher fares and operate at proportionately lower occupancies, if they could attract a sufficient clientele. The point to notice is that the required occupancy increases much less rapidly than bus size, so that the 70-seater requires an occupancy far below its capacity. The costs shown here allow for the fact that small buses will run marginally faster because passengers will board and alight less frequently. As noted above, they are based on a flat all-day service with no peaks. Provision of service peaks will increase the average costs and raise the required occupancies across the board, though here again small private operators might do relatively better than LT if they could use part-time labour to cover the peaks without incurring the penalties of split-shift or spread-over working.

Figure 1(b) shows how the cost per seat-km operated varies with bus size. It doubles as capacity falls from 70 to 20 seats under Middle costs, but then almost doubles again at 10 seats. This illustrates the disadvantage under which very small vehicles would have to work.

"OPTIMUM" BUS SIZE FOR THE PRESENT LT SERVICES

To set the scene, Figure 2 shows the net community benefit from the operation of buses of different sizes on the present LT network in Central London. For each size of bus, the amount of service provided is adjusted until the net benefit is maximised. An increase in service will cost more to operate, of course, and for a given level of subsidy it will require higher fares to be charged, but passengers will gain from a commensurate reduction in average waiting time. The increase in the number of buses operated is also assumed to add to average traffic flows and therefore, through a linear speed/flow assumption, to lead to a reduction in average speeds. Apart from this external disbenefit, maximum benefit would correspond to that combination of service and fares which maximised total patronage (at a specified level of subsidy). As it is, maximum benefit tends to occur at service levels slightly lower than those which would maximise patronage. Operation is divided into peak and off-peak periods, with marginal costs normally lower in the off-peak than in the peak, and demand more elastic in the off-peak than in the peak. The details of these assumptions can be found in Oldfield and Bly (1985). Benefit is measured in terms of reductions in the total generalised cost of travel for bus passengers (for whom the generalised cost combines the fare paid with the cost of time spent walking to the bus route, waiting for the bus to arrive, riding in the vehicle, and walking from the alighting stop to the destination) and for other road users (for whom the generalised cost combines vehicle operating cost and travelling time, which are both functions of average road
FIGURE 2

Net benefit from operating different sized buses on the Central London network under different costing assumptions
speed). These changes in generalised cost are summed by integrating them under the appropriate demand curves, which are defined by a constant elasticity of demand with respect to generalised cost, and which for bus passengers provide a demand elasticity relative to fares equal to $-0.18$ in the peak (that is, a fares increase of 1 per cent reduces patronage by 0.18 per cent) and $-0.36$ in the off-peak. These elasticities are relatively low because the high level of subsidy in 1981 kept fares low; the elasticities increase when subsidy is removed, as fares then form a larger fraction of generalised cost. This calculation of benefit measures the change in consumer surplus in the usual way. Any subsidy provided for the bus services is subtracted from the benefit to travellers since subsidy merely transfers cost from the passenger to the subsidising authority (though, since it can encourage more people to travel for the same overall cost, it can provide a net benefit of its own). The other resource costs of the operation are already covered by passenger revenues. In Figure 2 the discontinuity at a bus size of 55 seats is due to an assumed change at this point from single-decker to double-decker operation.

Figure 2 shows that, as one would expect, the net benefit is very sensitive to the costing assumptions, becoming larger as the services can be operated more cheaply. The “Base” curve shows the existing (1981) situation, with LT’s actual costs, 52 per cent of services using two-person crews, and some 45 per cent of total operating costs covered by subsidies. This curve does not show zero net benefit at the point which represents existing operations, because the model suggests that there would have been a small benefit to be gained by cutting services slightly and reducing the fares; in practice, however, the best balance between the amount of service offered and the fares charged depends on many practical details which are ignored in the aggregate approach of this work, and such small differences in benefit should be treated with caution. Maximum benefit is obtained with a bus size of around 60 seats; but again, because the modelling is based on averages, the difference between this and the current bus size of 70 seats is of no practical significance.

If the subsidy is removed there is a net disbenefit, though in the curve for High costs and no subsidy this has been offset somewhat by the conversion to 100 per cent OPO, which according to the model will give a net benefit equivalent to about 3 per cent of LT’s total operating cost. (Here again, the actual effect of full conversion to OPO is likely to depend on practical details which cannot be treated properly at this aggregate level.) The move to full OPO and no subsidy makes smaller buses relatively more advantageous, and the optimum size is about 50 seats. The Base cost calculations include an assumption that employing more crews will require an increase in average wages to attract sufficient extra staff. The relationship employed is one suggested by London Transport (TRRL, 1980), whereby a doubling of staff would require average wages to rise by one third. This consideration is, of course, likely to be more important in times of full employment. If the assumption is relaxed, so that the cost per driver remains constant regardless of the number of buses operated, the optimum bus size under High costs and full OPO falls to 40 seats, as Figure 2 shows.

The curves for Middle and Low cost assumptions are calculated on the basis of constant crew costs, regardless of the number of crews required: the optimum
bus size would have been about 10 seats higher if instead it had been assumed that crew wages increased with the number of crews required, as in the Base calculations. The Middle and Low cost curves are also based on 100 per cent OPO working and no subsidy, so they are directly comparable with the High cost curve with crew wages constant. Naturally, these assumptions reduce the optimum bus size, since they have greatly reduced the relative costs of operating smaller buses rather than large buses. With Low costs, the unit costs of very small buses have been halved, so it is to be expected that the net benefit will be as large as one half of LT’s total operating cost (loss of wages to operating staff is not included as a disbenefit in these calculations). The optimum bus size falls to 20 seats with these rather extreme cost assumptions, especially when in addition to Low costs it is assumed that crewing could be so flexible (because of part-time working) that it would be no more expensive to cover the peaks in service than to provide crews at other times of day. Even so, the net benefit falls rapidly at very small bus sizes, because of the high cost per seat-km and because the large number of small buses needed to provide adequate capacity adds appreciably to general traffic congestion. Thus a service network based entirely on small buses is unlikely to be desirable unless they can achieve a very large cost advantage over large buses. It is conceivable that, under the impetus of competition, greater flexibility of operation might achieve costs approaching the Low cost assumptions; but the same pressures are also likely to reduce the costs of big buses, so restoring the balance of advantage towards them. Nevertheless, as we shall see, there may be scope for small buses to compete with large ones.

MINIBUSES OPERATING ON ROUTES PHYSICALLY SEPARATE FROM LT SERVICES

The average flow of LT buses on routes in the Central Area is about 45 per hour. Thus the average headway is only 1.3 minutes. Yet the average passenger waiting time is about 6 minutes, because most of the buses passing a waiting passenger will not be going to his destination. Passengers seem to be able to catch about one bus in five. If minibuses services are to be introduced at an average flow much lower than that of the LT buses, we must ask how many different routes the minibuses will be serving, and therefore what proportion of all travellers will consider the minibuses to represent a real alternative to the big bus services. The rather arbitrary, but plausible, assumption made here is that, if the minibus flow is very low, only one fifth of all bus travellers will consider the minibus services to offer an alternative to the LT buses (that is, the modal split will apply to this fifth). As the flow increases, the minibuses are assumed to offer proportionately more services (on average: the discrete character of services is ignored here), appealing to a proportionately larger fraction of the travellers, until the modal split encompasses all travellers when the minibus flow equals that of LT. The average waiting time for the appropriate minibus service is assumed to fall as the flow of minibuses increases; it has a maximum value of 20 minutes at very low flows. This might seem unrealistically long, and indeed it is true that for long-headway services passengers will not spend a proportionately longer time waiting at the
stop. However, for the passenger infrequent services have a disadvantage which is not adequately represented by the increase in actual waiting time; and, given the presence of a much higher frequency alternative on the adjacent LT route, it seems not unreasonable to use a constant proportion in the calculation of generalised cost. The average waiting time is assumed to fall to a value midway between LT’s present average waiting time and the maximum of 20 minutes when the flow is equal to one fifth of the LT flow, and to be equal to the LT average when the flows of both types of buses are equal.

Demand has been categorised into three different distance markets, for travelers with mean in-bus distances of 1.5 km, 5.5 km and 8.0 km (in two separate bus stages of 4.0 km), because the competition varies somewhat within the different distance categories. As was explained in the introduction, the modal split mechanism has been made quite sharp: if one mode has a generalised cost 10 per cent greater than that of the other, it is assumed to attract about a third of the total demand for bus travel, but if its cost is twice that of the cheaper mode less than 2 per cent will use it. (The modal split coefficients which are obtained in typical calibrations of models of bus-versus-car modal choice would give figures of 45 per cent and 20 per cent respectively; but there are many reasons why this type of calibration tends to exaggerate the potential shift from car to bus. In the much clearer-cut situation of choice between two types of buses, the much sharper modal choice assumed here does not seem to be too hard on the more expensive mode.)

Under this set of assumptions and with Middle costs, the model finds that the minibus services would fail to cover their costs right across the spectrum of minibus flows, from low flows operating on a single service up to flows equivalent to LT’s operating on several different services. They could not be made profitable by raising fares, because in this competitive situation the fares elasticity rises to one, and revenue starts to fall with further fares increases, at a point some way below profitability (the minibus fares which provide maximum revenue are typically only 15 per cent or so higher than the LT fares). However, if the minibus services were able to offer some extra advantage over the LT services they would be able to charge higher fares and still remain competitive. The size of the advantage needed to enable the minibus services to break even is illustrated in Figure 3 for 20 seater buses for a range of bus flows. It can be seen that the required advantage is fairly small at about 2p/km if the minibus services are frequent. (The value also becomes small at very low minibus flows, but this is because the modal split function we have used suggests that some passengers will use the services even if they are very much more expensive (in terms of generalised cost) than LT services, and the patronage at such low flows is almost certainly overestimated.)

Thus the minibuses may find it difficult to attract sufficient revenue unless they can offer the traveller something extra. What might this be? The model already takes into account the effect of lower bus occupancies on the total time required for passengers to board and alight. But, since a substantial proportion of the big buses are two-person-operated, the one-person-operated minibuses are assumed to take longer, on average, to take on their passengers, so they have relatively little advantage in speed in spite of their smaller occupancies. In practice
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**FIGURE 3**

*Net benefit, and operating loss, when minibuses operate along routes which are separate from LT services ('Middle' costs, 20-seater buses)*
the calculation made here may be favourable to the small buses because it assumes that their passengers can board and alight as quickly as on a one-person-operated big bus, and one objection to minibuses is that they can be difficult to board, especially for the elderly. Typically, the minibuses run at a speed of about 0.5 to 1 km/h faster than the LT buses, which have an average speed of about 15 km/h, so the time saving on an average 4 km journey would be 0.5 to 1 minute, worth about 0.75 to 1.5 pence of generalised cost. This advantage is already included in the calculations, of course, but, if the competition were to be between the minibuses and wholly one-person-operated big buses (as in a provincial city), the speed advantage might increase to the equivalent of perhaps another 1p. This does little to close the gap between the two types of services, which will be about 8 pence for an average journey, even at high minibus flows.

It is also possible that the greater choice of routes provided by the minibuses, and especially their potential for penetrating residential areas along roads unsuited to large buses, may reduce average access time to the services beyond the assumption made here that, with the minibuses operating in the interstices between the LT routes, travellers could perhaps halve their walking distance to the route. Since the advantage required for the minibuses to break even is from 8 to 14 pence (depending on flow) for the average 4 km journey, the reduction in walking time required would be 3 to 5 minutes, equivalent to 250 to 400 metres. That does not seem to be beyond the bounds of possibility in some areas; but, given the already high route density in the Central Area of London, it seems very unlikely that it could be achieved generally. Another possibility is that the minibus services could offer better schedule reliability than LT, but LT estimates that about half its “excess waiting time” is due to traffic congestion and outside its control. If that is true, the minibus operator may be unable to achieve sufficient improvement in reliability to provide the required advantage.

The minibus operator may opt to offer greater comfort than the big buses, and adopt a generally “up-market” image. In terms of generalised cost, this would be represented by a reduction in the cost of time spent riding in the vehicle: since the total in-vehicle time component is equivalent to about 20p, a reduction by 8 pence is perhaps conceivable, though the 14 pence needed for low flows is less so. Moreover, purchase and maintenance of more luxurious vehicles would inevitably increase the costs of providing service.

Nevertheless, if the minibus services can offer a higher travel speed, either by achieving a higher speed on the road or by taking the passengers closer to their destinations (though the latter advantage is likely to be gained only at the expense of more indirect routing and longer in-vehicle times), they will appeal especially to travellers with a high value of time. The modelling described so far assumes the same value of time for all travellers. Repetition of the calculation for three groupings of travellers with values of time set at 0.6, 0.9 and 1.5 times the average did not suggest that, overall, this factor would make it significantly easier for small bus services to cover their costs, though where they could find a worthwhile saving in time they would attract proportionately more of the high value-of-time travellers.

It might be noted that if a less discriminating modal choice mechanism had been used the model would suggest that the minibuses would fare much better,
but for the reasons given earlier this approach seems unrealistic.

All this assumes that LT will continue to offer the same services, at the same fares, despite the revenue it will lose to the minibuses. This situation is of interest, because LT's Central Area services require less subsidy than its more peripheral operations, and the elimination of cross-subsidy, coupled perhaps with some reduction in operating costs in the face of competition, may well permit LT to continue operating the existing level of services on central routes when faced even with long-lasting competition. Operators challenged in this way are certainly likely to maintain services and fares over the shorter term; indeed, they may improve the services which face competition in order to preserve their market. If the competition survived for long enough, however, a loss of revenue which could not be offset by reductions in cost would eventually force the big bus operator to raise fares and/or reduce services. This would obviously benefit the minibuses. As curve B in Figure 3 shows, if LT cuts services to offset the fall in revenue, the result for the minibuses is to halve the shortfall between costs and revenue at high flows. Further, the gap between the generalised costs of travel by the two types of buses at high minibus flows has become almost negligible and would be easily covered by the uncertainty over what advantages minibus services might offer. Table 1 gives details of the predicted use and operating conditions of the services under both assumptions about the response of the existing operator.

Calculations of net social benefit based on average generalised costs of travel would suggest that there is a net disbenefit from introducing the new services, because a proportion of travellers switch to them and they have a higher average generalised cost than the older services. However, those travellers who switch do so because they gain a net advantage in spite of the higher average cost. The overall benefit can only be calculated by integrating the gain in consumer surplus of travellers who switch as the minibus services become more frequent and more competitive, assuming that at the margin where each traveller transfers there is no net benefit across the transition. This method of integrating the total benefit has been used to construct Figure 3, which shows that there could be positive benefits at large flows even if the small bus services could not cover their costs and had to be subsidised, provided that LT had to reduce services to hold its subsidy constant. This benefit depends upon the cost assumptions, however. It is gained only if the new services, under the Middle cost assumptions, are appreciably cheaper to operate than the big bus services, and if this saving offsets the fact that adding new services produces more service in total than is optimal. If, however, LT were to retain services at the existing level, the calculations of Figure 3 suggest that there would be a considerable net disbenefit if the minibuses were unable to cover their costs. On the other hand, if they could cover their costs by providing the additional travel time (or other) advantage necessary to attract sufficient passengers, there would be an appreciable net benefit even without any reduction in the LT services, since the benefit to the travellers who chose minibuses would obviously outweigh the costs in resources, and their consumer surplus would be larger than the disbenefits of the increased traffic congestion and the additional subsidy to LT services.

Benefits calculated in this way are, however, very dependent on the modal split parameter. If the modal choice had been more discriminating than that
<table>
<thead>
<tr>
<th>Flow of minibus services per hour</th>
<th>Assumed wait time for each service (minutes)</th>
<th>Proportion of market with minibus alternative</th>
<th>Mean generalised cost of travel (pence)</th>
<th>Mean occupancy share to minibus</th>
<th>Advantage minibus needs to break even (pence/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) LT services and fares held constant</td>
<td>2 6 18</td>
<td>0.23 0.44 0.66</td>
<td>83 79 78</td>
<td>0.02 0.12 0.25</td>
<td>7.1 5.9 5.9</td>
</tr>
<tr>
<td>(b) LT service reduced to hold subsidy constant</td>
<td>3 7 17</td>
<td>0.25 0.54 0.78</td>
<td>83 82 83</td>
<td>0.03 0.18 0.30</td>
<td>6.2 6.1 6.6</td>
</tr>
</tbody>
</table>

Excluding the extra advantage minibus would have to offer if they are to break even (see last column).

† Proportion of passengers who consider minibus as an alternative.

‡ LT fares stay constant at 5.1 pence/km.

§ Peak values only.
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assumed here, fewer people would have chosen the minibus services, which would have been less able to cover their costs. The net benefit would have been more negative. (At the limit, with a "black and white" modal split function, no one would use the minibus services because of the higher average cost, and the net disbenefit would simply equal the operating cost of the new services plus their effect on congestion.) With a wider modal split, on the other hand, both the benefit and the ability to cover costs would be larger; but, as noted previously, the assumption of a wide modal split function is likely to be misleading in a situation where the comparison can be fairly clear cut.

The results given here are based on 20-seater buses and Middle operating costs. If larger buses had been used, with their greater operating cost per vehicle-km, or if High operating costs were appropriate (and remember that these represent the existing cost variation by bus size), the benefits would have been more negative and breakeven harder to achieve. Conversely, smaller buses (15-seater, perhaps) would fare slightly better, but would still not cover their costs, even at high flows, unless they could offer some advantage beyond the travel times assumed in these calculations. Twenty-seaters operated at Low operating costs would be able to break even and could produce a net benefit equivalent to about 5 per cent of LT's total operating cost, even if the LT services were not reduced; but it seems unlikely that such low costs could be achieved in practice.

MINIBUS SERVICES SHARING THE SAME ROUTES WITH LT SERVICES

It was seen in the previous section that, if potential passengers are forced to choose between the two types of services when they start their journey, the minibuses may find it difficult to cover their costs unless they can offer some extra advantage in travel time over the LT services, and that the addition of these extra services may not bring net social benefit if LT continues to run the same services as at present. The situation is quite different, however, if the minibuses are allowed to pick up passengers who are waiting for LT services. In practice, of course, the two types of services are likely to have separate stopping places (as do different LT services at the moment); but, since LT's stops are typically 300 metres apart, it will generally be possible for travellers to place themselves within (at worst) 75 metres of both a minibus stop and an LT stop and to catch either type of bus, depending on which arrives first. Conversely, of course, the LT buses will pick up passengers who might have preferred a minibus, if that had arrived first.

If the two types of services were so similar that most travellers were indifferent to which one they used, then the problem would reduce to passengers catching the first bus to arrive (or, more properly, the first of the one-in-five buses that were going their way), provided, of course, that there was room on the bus for them. Under these assumptions the minibuses would have the same average occupancy as the LT buses if the bus arrivals were irregular and if passengers arrived at random. This is probably an adequate representation of the situation in Central London, where bus flows are high. (If minibuses are in competition with a single regularly scheduled service of big buses the problem is more complicated, and minibus occupancies will probably rise from half that of the big buses,
on average, to equality with that of the big buses when the two bus flows are equal.) If the mean big bus occupancy were larger than the minibus capacity, the minibuses would be running full along the most heavily-trafficked part of their route. Since LT's average occupancy is about 30 in the peak and 10 in the off-peak in the Central Area, it is clear from Figure 1 that minibus operators would have no difficulty in covering their costs. This situation has been modelled with allowance for the limited capacity of the buses and the probability that passengers will not be able to get on the first bus to arrive, but it does not add anything to the results of the more complex model described below.

This model considers the generalised cost of travel by the two types of buses and for the three categories of distances travelled by passengers. The same set of assumptions is used as for the modelling described in Section 4, but the decision about which type of bus to use is made at the point where the first bus appropriate to the passenger's journey (that is, the one-in-five of the LT flow) arrives at the stop. From the time of boarding the bus, it may be that the mean generalised cost of travel by the first bus to arrive will be higher than that for a bus of the other type; but in this case the "second-best" type has already arrived, and catching a bus of the preferred type will involve an additional waiting time which must be added to its (lower) generalised cost of travel from the time of boarding. Since buses of one type will be running in a sequence which is totally uncoordinated with that of the other type, the average interval between the arrival of one type and the arrival of the next will be equal to the average waiting time for the second type (this is true whether bus arrivals are completely regular, or completely random, or for distributions in between). For those passengers who find that a minibus is the first to arrive, the additional waiting time cost for a big bus is equivalent to 18 pence; this means that the first bus to arrive is highly preferred, unless the other type of service can offer a considerable advantage to the passenger. For some passengers it may, since approximately 10 per cent of passengers fall into the long-distance category (8 km) where a bus interchange is involved: in this category it has been assumed that the minibus services will be able to transport half the passengers to their destination without the need for any interchange, because the minibus services will offer routes which are not at present served by any single LT bus. Conversely, a similar proportion of passengers currently making long journeys by LT without any interchange are assumed to have to change if they use the minibus services. The results presented here assume an all-or-nothing choice between bus types, determined according to whether the generalised cost of the first bus to arrive is higher or lower than the expected generalised cost of the other type of bus.

Under these assumptions and with Middle operating costs, the small buses would find no difficulty in covering their costs. Figure 4 shows that there is also a net social benefit from this arrangement, provided the flow of minibuses is not too large, though at maximum the benefit is not very big (it is equal to about 5 per cent of LT's total Central Area operating costs). Fifteen to twenty-seater minibuses provide slightly more benefit than either 10-seaters or 25-seaters, but the net benefit is very insensitive to the size of the competing buses. If the minibuses constitute more than 40 per cent of the total bus flow (that is, if the minibus flow is more than two thirds of the LT bus flow) there is a net social
disbenefit. This is partly because the extra subsidy required to make up for LT's loss of revenue begins to outweigh benefits to passengers from the more frequent service, but also partly because the high bus flow makes traffic congestion appreciably worse: average road speed falls from 19.6 km/h with no minibuses to 19.2 km/h at the point where benefit turns to disbenefit. If the High operating costs were applicable, the minibuses would still find no difficulty in covering their costs if there were not too many of them (their ability to break even disappears when their flow reaches half the existing LT bus flow). But the maximum benefit is
only equal to one per cent of LT's operating costs. With Low operating costs, of course, the small buses would do relatively better than with Middle costs, and maximum benefit would reach 10 per cent of LT's total Central Area operating costs. The calculations assume that the same number of small buses operates throughout the day, so they rely on LT services to provide adequate capacity at peak times. However, even if the minibuses provided the same peak to off-peak ratio as the LT services, they would still be able to cover their costs, and could still confer a net benefit, unless their operating costs were very large.

Again, as in the previous section, this presupposes that big bus services and fares will continue unaltered, though the loss of revenue will have to be made up from somewhere. If, taking a longer-term view, it is assumed that the big bus services will have to operate at constant subsidy and that services must therefore be cut to offset the loss in revenue, then Figure 5 shows that much larger flows of minibuses will be justified, and the net social benefit will be much greater. Effectively, the relatively expensive big buses are being replaced by the relatively cheap small buses (but note that the small buses remain more expensive in cost per seat-km). If too many 20-seaters are operated, however, the benefit starts to fall as operating cost and traffic congestion become too great. This is to be expected because, under our assumptions, 20-seaters are well below the optimum size for a one-bus-size service (see Figure 2), while 70-seaters are above it.
MINIBUSES AND REGULAR BUS SERVICES  

Thus where the competing services are able to serve the same passengers as the existing bus services they are likely to attract sufficient passengers under most conditions to cover their costs. Unless their operating costs are high, this will continue to be true even at high minibus flows where there would be a net social disbenefit, since though the mean occupancy of the big bus suffers markedly, the minibuses still have relatively high occupancies and in the with-peak direction the load factors are close to unity. Table 2 summarises the predictions of the model for minibus services operated in conjunction with standard services in this way, using 20-seater buses and the Middle cost assumptions.

SUMMARY

Clearly, attempting to represent transport and travel behaviour with these very simple, aggregate models is an uncertain process, and the results should not be taken too literally. Even when the models suggest that minibuses would fail to break even, there will in practice be areas and routes where they will prosper because local conditions are right for them, or because they can concentrate on a section of the market which is not well served at present. Conversely, the existing operator may be able to respond to competition in a way which has not been modelled here but which makes it harder for the competing minibuses to cover their costs — perhaps by providing new types of services altogether. Nevertheless, the distinction the modelling illustrates between the two types of operating conditions, with minibus services physically separate from the standard bus services, on the one hand, and with both types of services sharing the same routes, on the other, is probably real enough. Small buses start with the disadvantage of a relatively high cost per seat-km, and to compete with existing stage services they will have to offer something more than mere novelty. Where the two types of services operate on different routes, if minibuses are to attract sufficient revenue to cover their costs they will have to operate at a comparable frequency to the big buses, and they will probably need to offer some appreciable advantage perhaps in higher travel speeds, better penetration of residential areas, better reliability or greater comfort. Within the constraints of fixed-route services, it is not clear that they will be able to achieve these advantages.

On the other hand, if minibuses share the same routes as the big buses, so that a large proportion of passengers will be able to choose their bus when they have already arrived at the route, passengers will tend to catch the first suitable bus to arrive, regardless of its type. Under these conditions, minibuses are likely to do very well, achieving high average occupancies and covering their costs at very competitive fares. Provided the flow of minibuses is not too high, so that they do not cause too much traffic congestion or undermine the big bus occupancies too seriously, the mixture is likely to produce a small net social benefit.

The analysis described here has concentrated on small buses in competition with existing big-bus services because of the AMOS application to operate minibuses in London, but also more generally because the Government's intention to deregulate stage bus services in Britain has engendered renewed interest in the operation of small buses. Where they operate on the same routes, the minibus
TABLE 2
Minibuses and Big Buses Sharing Same Routes
(20-seater minibuses, "Middle" cost assumptions)

<table>
<thead>
<tr>
<th>Flow of minibuses per hour</th>
<th>Mean generalised cost of travel* (pence)</th>
<th>Modal share to minibus*</th>
<th>Mean occupancy (all-day average)</th>
<th>Minibus fare to break-even† (pence/km)</th>
<th>Flow of LT buses per hour*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LT</td>
<td>minibus</td>
<td>LT</td>
<td>minibus</td>
<td>LT</td>
</tr>
<tr>
<td>(a) LT services and fares held constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>85</td>
<td>83</td>
<td>0.03</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>83</td>
<td>83</td>
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<td>10</td>
</tr>
<tr>
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<td>81</td>
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<td>0.17</td>
<td>14</td>
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</tr>
<tr>
<td>20</td>
<td>80</td>
<td>83</td>
<td>0.24</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>(b) LT service reduced to hold subsidy constant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>85</td>
<td>83</td>
<td>0.05</td>
<td>16</td>
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<tr>
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<td>84</td>
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<td>81</td>
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<td>0.27</td>
<td>14</td>
<td>9</td>
</tr>
</tbody>
</table>

* Peak values only.
† LT fares remain at 5.1 pence/km.
MINIBUSES AND REGULAR BUS SERVICES

services assumed here have an advantage over even subsidised big-bus operations in offering a lower cost per passenger carried at the relatively low average occupancies typical of most services (see Figure 1). In this situation, their inadequate capacity to cope with either temporal or spatial peaks in demand, which might normally be a disadvantage of small size, is immaterial because the big-bus services continue to provide the necessary capacity. The modelling represents peak and off-peak periods, albeit very crudely, but its averaging processes do not take account of peaking along the route, so the average occupancies achieved by the small buses might in practice be slightly smaller than is calculated here. Nevertheless, it seems clear that they would generally be able to attract enough revenue to cover their costs, especially since they can charge fares somewhat higher than those of the big buses, provided the differential is not so great as to encourage too many passengers to wait for the next big bus. Glaister (1985) came to very similar overall conclusions about the viability of small bus services in competition with existing big bus services, but the details of his modelling were rather different from those reported here. In particular, his small buses succeeded by operating at very low occupancies and rather high fares, attracting travellers with relatively high values of time by virtue of the faster bus running speeds. The modelling described here suggests that minibuses would do well without necessarily attempting to segment the market, since most passengers are likely to accept the first bus to arrive even if it charges a little more. Indeed, categorising the market by value of time did not appreciably improve the profitability of the minibus services.

On many high-demand corridors, new operators competing with existing operators would still be able to cover their costs even by using conventionally large buses. The advantage of the small bus lies not merely in lower cost per average passenger load but also in the fact that, for a given outlay, the operator can afford to operate more buses, thereby collecting a proportionately larger share of all passengers along the route. Of course, faced with this competition the existing operator, if he cannot find sufficient cost savings, may be forced to reduce his own services considerably, and might ultimately be forced out of the market altogether if the competitor expands further. In this case, the peakiness of the demand might make minibuses less suitable than larger buses. The best size for a monopoly operator would be not very different from the “social optimum” calculated in an earlier section for the present LT services, but it might be necessary to retain the smaller buses in order to prevent another competitor from gaining advantage by using the same tactic which he himself had proved successful.

REFERENCES


