TRANSPORT RESEARCH LABORATORY

Concessionary fares: trip generation among elderly passengers

Prepared for Economics, Local Transport and General Division, Department of the Environment, Transport and the Regions

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Executive Summary

Under current legislation (Transport Act 1985), local authorities may provide concessionary travel arrangements for women aged 60 years or more and men aged 65 years or more. Authorities running such schemes are required to reimburse transport operators for any consequent loss of revenue, and any costs of provision of additional capacity needed to accommodate concessionary travellers. In the calculation of lost revenue proper allowance must be made for *additional revenue resulting from journeys generated by the concessionary fare scheme*, that is journeys which would not be made at all in the absence of the scheme. Such generated journeys should also be taken into account when determining any additional costs.

Reliable estimates of 'generation factors' are essential for negotiations between operators and authorities, since small differences in estimates can imply large differences in reimbursement. However, in practice they have proved difficult to determine. The results of previous studies, including cross-sectional analysis and trip rate comparisons before and after significant changes in concessionary schemes, have been widely divergent, and of limited value in indicating how generation factors should be determined in practice.

In 1995 the Department of Transport commissioned the Transport Research Laboratory (TRL) to attempt to resolve some of the uncertainty by means of a three-part research programme, comprising:

1 Comparison of bus use by elderly people in matched pairs of areas with different concessionary fare schemes. Seven day travel diaries were completed by about 300 people in each area: Tilehurst (in Reading) and Woodley (adjacent to Reading) in Berkshire; and Fishponds (in Bristol) and Kingswood (adjacent to Bristol) in Avon. Tilehurst residents of qualifying age received passes permitting free travel on buses, while those in Fishponds were allowed to travel at discounted fares (approximately two-thirds of full adult fares). Tokens were issued to people of qualifying age in Kingswood, and those in Woodley whose household incomes were below a specified threshold.

2 Examination of data from the latest National Travel Survey (NTS); this involved comparison of bus trip rates by people aged 50 years or more (including many not qualifying for concessionary travel), living in areas with different types of concessions and different levels of bus service;

3 Systematic examination of changes over time in concessionary travel in eight major urban areas (including three metropolitan counties) where significant changes in concessionary fare schemes had occurred in recent years. In all these areas time series statistics of total concessionary travel by elderly people were made available by operators or Passenger Transport Executives; in some areas disaggregate data (ie differentiated by trip length) were also available.

In view of the wide range of results obtained in previous research studies, it is not surprising that we have been unable to solve all the problems and remove all the uncertainties. We have, however, been able to identify those factors which are most important in determining public transport use by elderly people, and to indicate how they should be taken into account.

The most important influence on bus use is car ownership. Age, income and sex have a major influence on car ownership, but once this is taken into account the first three factors contribute little to explaining levels of public transport use.

The effect of bus service levels has been more difficult to establish. It appears that increasing frequencies to more than two buses per hour may not strongly affect demand by elderly people, but the available evidence is insufficient to provide an unambiguous measure. In practice, this residual uncertainty does not substantially influence the estimation of generated travel.

Fares were also found to influence demand, and this effect is of crucial importance in the estimation of generated travel. All types of concession - free travel, low flat fares, discounted (most commonly half) fares and tokens - were found to generate demand by elderly people, although the evidence on the effects of tokens is difficult to interpret, and provides no clear indication of the magnitude of resulting generated travel.

The results of the three approaches to the research - comparison of bus use in matched pairs of areas, analysis of NTS data, and analysis of data from selected urban areas - are far from completely consistent, but neither are they completely incompatible, and they tend to present a consistent account of the generative effects of different types of concessionary fare scheme.

Changes in concessionary fare schemes can have differential effects on numbers of journeys made over different distances (with different full fares), with some redistribution of journey lengths as concessions change. This has implications for reimbursement where different operators run different types of service, as generation factors may depend on journey length. We have been unable to model these effects convincingly, as the available data were somewhat limited, and important external factors could not be quantified.

Analysis of aggregate demand data from urban areas, over periods when concessions have been changed, produces somewhat higher estimates of generation factors than the formula resulting from regression analysis of the NTS data. A major concern about the former method is its dependence on extrapolation from low fare to full fares. The NTS analysis avoids this problem, but may be subject to other flaws which we have not been able to identify.

Nevertheless, the NTS formula provides a tool which, when used in conjunction with local data on car ownership, employment and average fares, can be used to provide a first estimate of generation factors in any area. Where changes in aggregate demand data can be related to changes in concessions (and any other relevant factors), they may be used to confirm or modify the results obtained using the NTS formula.

1 Introduction

1.1 The research programme

Under current legislation (Transport Act 1985), local authorities may provide concessionary travel arrangements for women aged 60 years or more and men aged 65 years or more[1]. Authorities running such schemes are required to reimburse transport operators for any consequent loss of revenue, and any costs of provision of additional capacity needed to accommodate concessionary travellers. In the calculation of lost revenue proper allowance must be made for *additional revenue resulting from journeys generated by the concessionary fare scheme*, that is journeys which would not be made at all in the absence of the scheme. Such generated journeys should also be taken into account when determining any additional costs.

Reliable estimates of 'generation factors' are essential for negotiations between operators and authorities, since small differences in estimates can imply large differences in reimbursement. However, in practice they have proved difficult to determine. A number of cross-sectional studies have been made (eg Goodwin et al 1988; O'Reilly 1990), but variations between different places in factors not directly related to fare concessions complicate analysis and the results can only indicate fairly wide ranges for generation factors.

Another approach is to analyse changes in demand for concessionary travel when there are significant changes in schemes. Such a 'before and after' study was made when concessionaires were charged a flat fare instead of travelling free in Tyne and Wear (Balcombe and Astrop 1995). Various difficulties in interpreting the results of these surveys led to a considerable degree of uncertainty in the generation factor derived from it, which was substantially higher than that which had been used in previous reimbursement calculations, and higher than those found in previous research.

In 1995 the Department of Transport commissioned the Transport Research Laboratory (TRL) to attempt to resolve some of the uncertainty by means of a three-part research programme, comprising:

1 Comparison of bus use by elderly people in matched pairs of areas with different concessionary fare schemes;

2 Examination of data from the latest National Travel Survey; and

3 Systematic examination of changes over time in concessionary travel in major urban areas.

This report describes each of these components of the research programme in turn, together with the results. Comparisons are then made between the results, and implications for estimation of generated travel are discussed.

1.2 Generation and reimbursement factors

It is useful at this point to define the terms 'generation factor' and 'reimbursement factor' which are used repeatedly in this report. There is no standard terminology, which can lead to confusion when comparing results of different researches if differences between definitions are ignored. Throughout this report the generation factor is defined as:

(1)

where n_C is the number of concessionary journeys (per week, year etc) in the area of interest, and n_N is the number of journeys *the same people would make in the absence of a concessionary scheme*[2].

The term 'reimbursement factor', defined as:

(2)

is often used for purposes of determining reimbursement to operators. If f_C and f_N represent fares with and without concessions the corresponding revenues would be $n_C f_C$ and $n_N f_N$. The difference, payable to the operator would be:

(3)

This signifies that for each concessionary journey the operator should receive reimbursement equal to the difference between the non-concessionary fare reduced by the reimbursement factor and the concessionary fare.

Ordinary and concessionary fares often vary with journey length, so in principle the calculation should be performed separately for each fare band. The practical implications of such a procedure are discussed in due course.

2 Local studies in matched areas

2.1 The areas

The basic objective of these studies was to compare bus use by elderly people who were allowed to travel free with others who had to pay full fares, and others who paid intermediate fares. As far as possible, the study areas were chosen to be similar in all relevant characteristics save for concessionary fare schemes. This led us to pairs of places which are parts of the same urban or suburban area, with similar demographic characteristics and bus services, but lying in different local authority areas with different concessionary fare schemes.

Our choice was constrained by the small number of free schemes, and the non-existence of neighbouring areas without schemes. Nevertheless, it was possible to find one 'matched pair' which partially fulfilled our requirements. This comprised Tilehurst, part of the Borough of Reading, and Woodley, part of the District of Wokingham, both in Berkshire. Reading still offers free concessionary travel to elderly people, within the Borough; elderly residents of Wokingham District qualify for National Travel Tokens if their incomes are not more than £103 per week for single person households, or £184 per week for couples. At the time of the study the annual allocation of tokens, issued in

April, was worth £68. It was anticipated that by the time the survey occurred (September 1995), many of the concessionaires would have used all their tokens, and would be behaving as if there were no concessions. The socio-economic structure of Woodley and Tilehurst are broadly similar, and both receive similar levels of bus service provision. The study area boundaries, their location relative to the centre of Reading and the bus routes are shown in Figure 1.

A second 'matched pair' was selected in order to compare alternative concessionary schemes. This pair comprised Fishponds, part of the City of Bristol, and the urban part of the District of Kingswood, which lies on the other side of the City boundary.

In Bristol, the elderly people receive bus passes allowing reduced fare travel (approximately one-third off) within the city of Bristol. Elderly people in Kingswood were entitled to £31 worth of National Travel Tokens per annum. Kingswood is similar to Fishponds in terms of access to public transport provision and socio-economic characteristics. The study area boundaries, their location relative to the centre of Bristol and the bus routes are shown in Figure 2.

2.2 The surveys

The surveys took place in September 1995. In each of the four areas, samples of people of pensionable age were asked to complete travel diaries listing the journeys they made over a seven day time period, omitting walking trips of less than 5 minutes. The respondents were also asked questions relating to their household structure and income.

To control the recruitment and to ensure a representative spread across the entire locality, each of the four areas was divided into sectors to be covered by the interviewers. The start day for the diaries was evenly distributed across weekdays and weekends. Respondents were selected according to quotas set on age and sex (see below):

- Women aged 60-64
- Women aged 65+
- Men aged 65+

The target response was 300 completed diaries in each of the four areas, with approximately one-third from each of the relevant groups shown above.

In order to be eligible to participate in the survey, the respondents had to fulfil the following criteria:

1 live within the boundaries of the area covered

2 agree to complete the diary over the next seven days

3 have travelled on local buses within the last 6 months

Although the survey related to concessionary travel, it was not a condition of recruitment that people were entitled to, or elected to receive concessions.

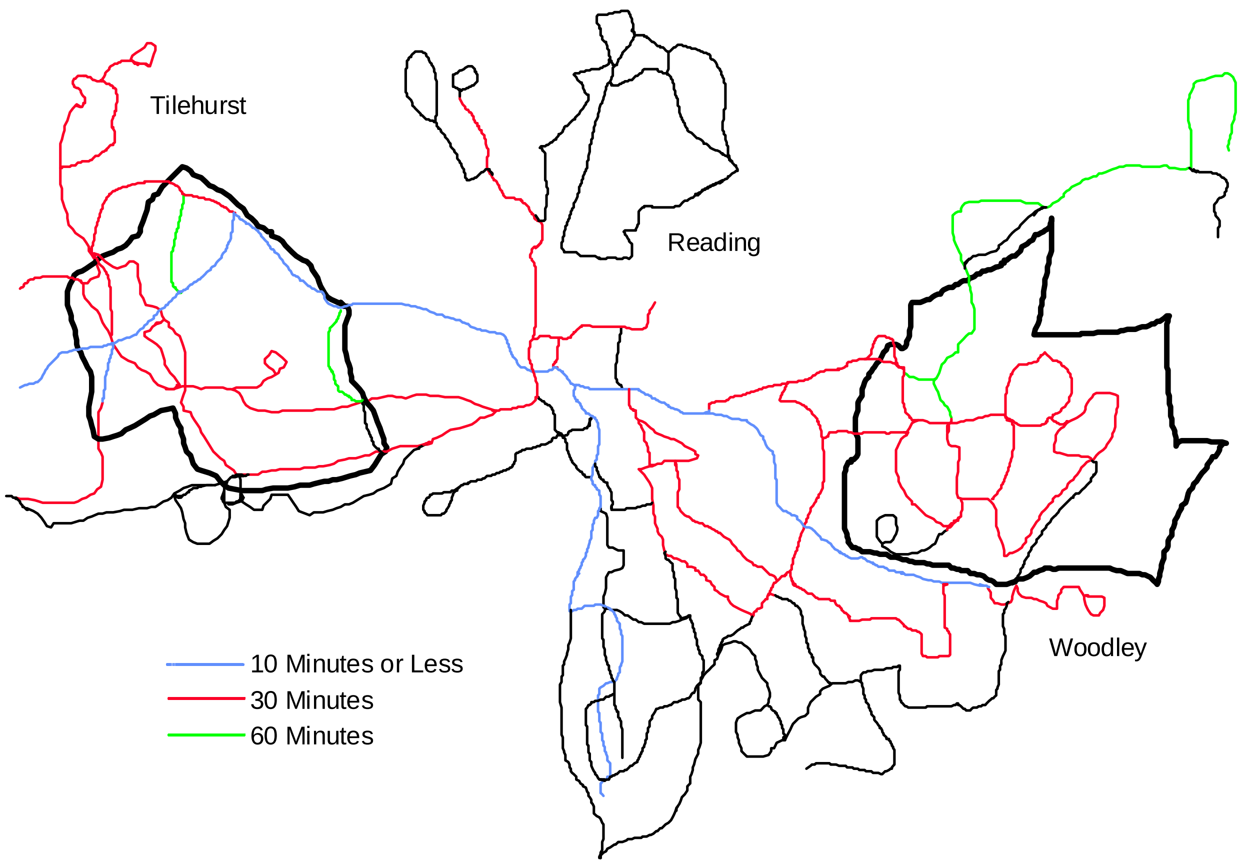


Figure 1 Tilehurst and Woodley study areas

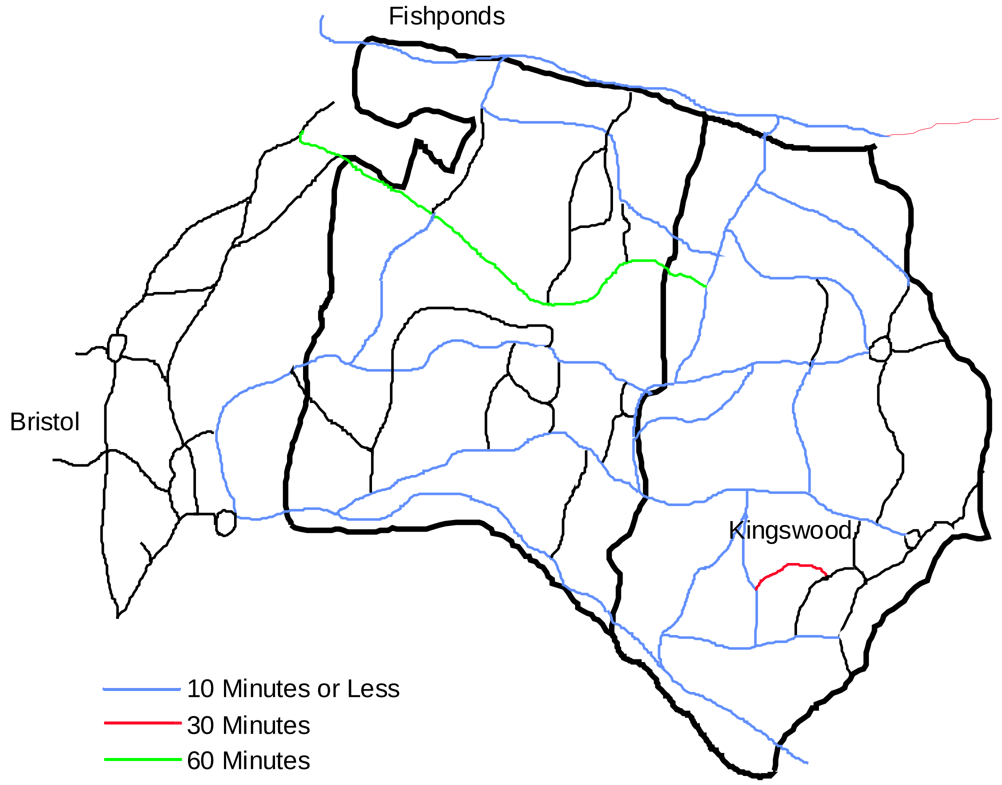


Figure 2 Fishponds and Kingswood study areas

2.3 Household characteristics

2.3.1 Household composition

2.3.1.1 Household size

Between 88 and 92 per cent of respondents in the four study areas completing travel diaries were members of one- or two-person households, and in this respect may be regarded as typical of people in this age group. The minority of people living in larger households are likely to have different travel habits: for example, household shopping may be done by others, and larger households are more likely to own cars. Further, there are too few of such respondents for separate statistical analysis, so they have been excluded from further consideration, and the rest of this report relates to one- or two-person households.

Table 1 shows the percentage of respondents in one-person and two-person households. Over 60 per cent of the respondents in all areas except Kingswood live in two-person households.

Table 1 Respondents in one- and two-person households

	Berkshire		*Avon*	
	Tilehurst (%)	*Woodley (%)*	*Fishponds (%)*	*Kingswood (%)*
1-person HH	34.4	38.7	35.2	42.8
2-person HH	65.6	61.3	64.8	57.2
Sample size	291	284	287	283

(excluding larger households)

2.3.1.2 Age and sex of respondents

Table 2 shows the distribution of respondents between women aged 60-64 years, women and men 65 aged 65 years and over. The proportions are roughly equal in all areas, but the younger women are slightly under-represented since they proved difficult to find.

Table 2 Completed diaries by area and age group *(one- or two-person households only)*

	Berkshire		*Avon*	
	Tilehurst	*Woodley*	*Fishponds*	*Kingswood*
women 60-64	29.2	28.2	21.3	25.4
women 65+	37.8	37.6	44.3	42.8
men 65+	33.0	34.2	34.5	31.8
Sample size	291	284	287	283

2.3.1.3 Occupation of respondents

Table 3 shows that most respondents in all areas described themselves as fully retired.

2.3.1.4 Residential stability

Between 87 and 92 per cent of respondents had lived in their respective study areas for over 10 years. It therefore seems reasonable to suppose that most would have been familiar with their local environment, and public transport facilities.

Table 3 Occupational status of respondents

	Tilehurst	Woodley	Fishponds	Kingswood
F/T paid work (not at home)	4	8	0	3
F/T paid work (at home)	0	0	0	0
P/T paid work (not at home)	13	11	6	7
P/T paid work (at home)	0	2	2	3
Unemployed	0	0	0	0
Fully Retired	216	184	261	260
Keeping House	54	70	16	7
Other	2	2	0	1
Don't know	2	7	2	2
Total	291	284	287	283

2.3.2 Economic factors

2.3.2.1 Socio-economic groups

The socio-economic groups of the respondents are shown in Table 4. Although there are differences between Berkshire and Avon, comparison of Tilehurst with Woodley, and Kingswood with Fishponds show that the pairs of areas are broadly similar in terms of social groupings. In Berkshire, a larger proportion of respondents were in the AB socio-economic group than in Avon. There are similar numbers in groups C1, but a high proportion in group DE in Avon.

Table 4 Socio-economic groups of respondents *(percentage of respondents in each group)*

SEG	Tilehurst	Woodley	Fishponds	Kingswood
AB	15.5	14.4	1.7	3.2
C1	20.6	26.8	21.6	19.4
C2	27.8	21.8	32.4	30.7
DE	36.1	37.0	44.3	46.6

2.3.2.2 Income

Table 5 shows the distribution of household incomes in each area. The Berkshire respondents are generally more affluent than those in Avon. The Tilehurst and Woodley distributions appear to be quite well matched, but there is a greater proportion in the lowest income group in Kingswood than in Fishponds. The relatively high proportion of people who were unable or unwilling to state their household incomes is of concern as it is not known whether these people were typical of the rest, or, if not, whether their exclusion significantly distorts the distribution. We shall return to this point later in the report.

2.3.3 Mobility factors

2.3.3.1 Car availability

The proportions of respondents in car-owning and non-car-owning households are shown in Table 6.

The proportion of households with no vehicle is somewhat greater in Tilehurst than in Woodley; in Kingswood and Fishponds the proportions in each of the categories are broadly similar.

Table 7 shows the proportion of households with one or more car by income band (for respondents who provided this information). There is a clear correlation between income level and car ownership in each of the areas, but sample sizes are too small to allow much useful comparison between areas, especially among lower income groups. However, in the higher income groups (£10000 or more), there is a tendency towards higher car ownership levels in Berkshire than in Avon.

Table 5 Household income from all sources *(percentage of respondents in each income range)*

	Berkshire		Avon	
	Tilehurst	Woodley	Fishponds	Kingswood
£4999 or less	23.4	22.8	36.9	41.6
£5k-9999	31.7	31.0	30.0	25.8
£10k-14999	11.3	11.6	6.3	5.7
£15k-19999	5.5	6.0	1.7	4.6
£20k-24999	1.7	1.1	0.0	1.1
£25k-39999	1.7	0.4	0.0	0.0
Refused	12.7	19.0	16.0	13.1
Don't know	12.0	8.1	9.1	8.1
Total	100	100	100	100

Table 6 Household car availability *(percentage of respondents)*

Number of cars/vans	Tilehurst	Woodley	Fishponds	Kingswood
0	49.5	41.9	60.6	61.5
1	48.1	51.8	37.3	36.0
2 or more	2.4	6.3	2.1	2.5

Table 7 Dependence of car ownership on household income *(percentage of respondents with one or more cars)*

Household income	Berkshire		Avon	
	Tilehurst	Woodley	Fishponds	Kingswood
£4999 or less	19.1	27.7	22.6	23.7
£5k-9999	45.6	55.7	46.5	43.8
£10k-14999	87.9	81.8	61.1	68.8
£15k or more	96.2	100.0	80.0	68.8

2.3.3.2 Travel concessions

The great majority of respondents had travel concessions (Table 8), except in Woodley where eligibility is income dependent.

In each area a small minority of respondents claimed to have some non-standard form of concession. Some of these were unidentifiable, others appeared to have been cited in error. These respondents are ignored in subsequent analysis in this report.

Reasons for not having travel concessions are shown in Table 9. In Woodley, 115 respondents stated that they were not eligible for tokens. However, 22 of these people had declared incomes below the eligibility thresholds (£103 per week for single people or £184 per week for

Table 8 Respondents with concessions* (%)

	Berkshire		Avon	
	Tilehurst	*Woodley*	*Fishponds*	*Kingswood*
None	1.4%	51.0%	9.4%	2.8%
Free pass	96.9%		0.7%	
Reduced fare pass	1.0%		87.8%	
Travel tokens		47.2%	1.7%	96.8%
Other travel allowance	0.7%	1.8%	0.4%	0.4%
Total	100%	100%	100%	100%

**Including those who had run out of tokens*

couples). A further 14 respondents stated that they were unaware of the token scheme. This may be a reflection on the effectiveness of publicity about the scheme.

Table 9 Reasons for not having a pass/tokens*

	Berkshire		Avon	
	Tilehurst (free pass)	*Woodley (tokens, if eligible)*	*Fishponds (reduced fare pass)*	*Kingswood (tokens)*
Not eligible	1	115	3	1
Don't use very often	2	9	17	1
Use car/ no need		1	4	4
Other		3	5	1
Don't know	2	3	4	1
Bus routes not suitable		1		
Not aware of them		14	1	2
A lot of forms		5		
Health problems/ physical difficulties			1	
Bus times unsuitable			1	
Total	5	151	36	10

**These numbers exclude people who had run out of tokens by the time of the survey and may differ from the number of respondents without tokens as some respondents gave more than one reason for not having travel tokens.*

In Woodley, tokens are issued annually in April. By the time of the survey in September, all but six respondents still had some tokens, the average value of the residue being £27.75[3]. Allowing for the likelihood of a diminution of trip rates in the winter months, it would appear that most people were likely to make their tokens last for most of the year, rather than using them all in the first few months, either by making more frequent bus trips, or spending them on more expensive forms of transport like taxis or trains.

In Kingswood tokens are also issued in April. Only forty-nine of those eligible had run out of tokens by September, with the remainder still holding tokens with an average value of £12.60.

2.3.3.3 Bus fare payments

Table 10 shows whether and how respondents paid for journeys by bus. In Tilehurst, virtually all the respondents used free passes. In Woodley over half the respondents who made journeys during the survey week used cash to pay the full fare. In Kingswood, although a greater proportion of the respondents had used up their allocations of tokens, more of them used tokens to pay for their journeys than in Woodley, because more of them were eligible for tokens.

Table 10 Payments for public transport journeys

	Berkshire		Avon	
	Tilehurst (free pass)	*Woodley (tokens, if eligible)*	*Fishponds (reduced fare pass)*	*Kingswood (tokens)*
Full cash fare	6	84	16	58
Pass/free	238			
Pass/reduced			143	
OAP Tokens/free travel		75		99
Other person paid	1	2		
Tokens and cash		21		69
No journeys during survey week	46	102	128	57
Total	291	284	287	283

2.3.3.4 Problems with bus use

Recruitment of survey respondents was limited to people in the appropriate age groups who had used a bus within the last six months, and who were considered capable of answering all the questions and completing the travel diary. Except for people who had recently suffered deteriorating health, all respondents should have been capable of using buses. However, many elderly passengers experience problems in using buses, so all respondents were asked whether they had difficulties and, if so, what was the nature of them.

Table 11 indicates the main problems reported. Although levels of bus service provision were broadly similar in Woodley and Tilehurst, there were far more complaints from Woodley respondents (32 per cent of respondents compared with 11 per cent) mostly about the inconvenience of bus services. The level of complaints in Fishponds (22 per cent of respondents) and Kingswood (19 per cent) was intermediate between those in Tilehurst and Woodley.

Table 11 Main problems in using local buses* *(numbers of respondents)*

	Berkshire		Avon	
	Tilehurst	*Woodley*	*Fishponds*	*Kingswood*
Inconvenient	22	83	43	40
Physical Problems	9	21	22	17
Unreliable	3	12	16	7
Not enough tokens		2		5
Other	5	5	7	4
Don't know		2	1	

**These figures add up to more than the number of respondents who had reported problems because some respondents gave more than one answer*

There is no obvious objective reason why bus services in Woodley should be regarded as less convenient than those elsewhere. One hypothesis considered was that buses may appear less convenient to people accustomed to using cars, and levels of car ownership are higher in Woodley. But, as Table 12 indicates, there is no significant correlation between car ownership and the level of complaints. An alternative explanation is that people are more likely to complain about services they have to pay for (and fewer than half of the Woodley respondents enjoyed any form of concession) than free services. This might also explain why far fewer Tilehurst respondents cite physical problems than those elsewhere.

Table 12 Problems for car owners and others in using buses *(percentage of respondents)*

	Berkshire		*Avon*	
	Tilehurst	*Woodley*	*Kingswood*	*Fishponds*
Car(s) in household	8.2%	33.9%	19.3%	18.6%
No car(s) in household	13.9%	29.4%	18.4%	23.6%

It appears surprising that, in all four areas, only seven respondents cited any form of financial barrier to using buses (‘not enough tokens’).

2.4 Trip rates

Table 13 shows the mean number of journeys by each mode of transport recorded during the survey week by respondents in each study area. The overall trip rates by all modes are remarkably similar.

Table 13 Mean number of journeys by mode of travel

	Berkshire		*Avon*	
	Tilehurst	*Woodley*	*Kingswood*	*Fishponds*
Car (see below)	8.6	10.6	8.1	7.7
Walk	5.8	6.8	7.0	7.6
Bus	6.1	2.3	5.0	3.3
All other modes (see below)	0.5	1.4	0.3	0.5
All trips	21.0	21.1	20.4	19.1
Other modes				
Bicycle	0.2	1.0	0.1	0.2
Coach	0.1	0.2	0.1	0.2
Motorcycle	0.1	0.06	0.02	0.003
Taxi	0.03	0.09	0.1	0.03
Train	0.06	0.05	0.01	0.04
Car				
Driver HH car	5.3	6.8	4.9	4.6
passenger HH car	1.8	2.4	1.1	1.3
passenger in other private car	1.5	1.4	2.1	1.8

The most commonly used forms of transport are car (as driver or passenger), walking or bus; other modes account for fewer than 0.5 trips per person per week, except in Woodley where respondents averaged 1.0 cycle trips per week each (possibly because of the relatively flat terrain there). It is clear that the minor modes have a negligible influence on the way in which journeys are distributed between car, walking and bus, and in any case there are insufficient data on them for useful statistical analysis, so they are not considered further in this report.

In each area most trips were made by car, and more trips were made on foot than by bus, except in Tilehurst. The greatest use of cars and the least use of buses are in Woodley, where car ownership is highest, and concessionary bus travel is available to only about half the respondents. Comparison between Woodley and Tilehurst suggests that bus trips are substituted for car, walk and cycle trips where free bus travel is available to all elderly people.

Most use of cars is made by drivers. In Tilehurst and Woodley, more trips are made as passengers in household cars than in other private cars; the reverse is true in Fishponds and Kingswood, where car ownership levels are lower.

2.5 Factors influencing bus use

Our primary concern in this study is to discover the extent to which bus use is affected by various types of fare concession, but it is clear from the preceding section that other factors are also likely to be influential, and must be properly allowed for if the true effects of concessions are to be discerned.

2.5.1 Car ownership

Table 14 shows trip rates by the major modes for people in car-owning and no-car-owning households in all areas. The general effect of car ownership is similar in all areas: members of car-owning households make more trips in total than others. Difference in overall trip rates result from much greater car use (in excess of ten more car trips per week), which are partially offset by more trips on foot and by bus by non-car-owning households. In particular, bus trip rates for carless respondents are much greater than those for people with cars.

Table 14 Weekly trip rates: effect of car ownership

Transport mode	*Tilehurst*	*Woodley*	*Fishponds*	*Kingswood*
No car				
All car journeys	2.4	2.5	2.6	3.4
Walk	6.6	8.6	7.5	8.4
Bus	8.2	3.7	5.1	7.1
Other	0.5	1.1	0.3	0.4
All modes	17.7	15.9	15.5	19.3
Car				
All car journeys	13.1	14.9	12.7	13.8
Walk	5.2	5.8	7.7	5.2
Bus	4.6	1.5	1.5	2.5
Other	0.2	1.2	0.3	0.3
All modes	22.9	23.4	22.2	21.8

The most striking difference between areas are in trip rates by bus: these are highest, for both car owners and others, in Tilehurst, with the most generous concessions, and lowest in Woodley, where over half the respondents enjoy no concessions. Further analysis of these differences is postponed until other factors have been explored.

However, it is abundantly clear from Table 14 that the travel habits of car-owning-households and others are quite different, and that failure to take this difference into account would confuse any attempt to identify the effects of different types of travel concession. In the rest of this report we therefore treat the two groups separately.

2.5.2 Income

There are various reasons why income might affect people's use of buses. The most obvious relates to car ownership: as Table 7 shows, car ownership is strongly correlated with household income, so that generally bus trip rates would be expected to be lower for people on higher incomes. However, we can isolate this effect by considering car owners and others separately. Other effects are less clear. Less affluent people are less likely to be able to afford the activities (shopping, leisure pursuits) to which buses might take them, and, where bus travel is not free, less willing to pay fares; those running cars on low incomes might be inclined to use them sparingly. On the other hand, those on higher incomes may be able to afford alternatives to bus travel, even if they do not own cars.

Table 15 shows trip bus trip rates in the four areas, according to car ownership and income level. Respondents in Woodley have been separated according to whether they were issued with concessionary travel tokens. This factor is almost entirely dependent on income, but there are a few anomalous cases of people whose incomes are apparently above the threshold for concessions but who nevertheless have obtained them. This may be due in part to confusion over household income, which as we suggested earlier (section 2.3.2.2) may not always have been accurately reported, and whose distribution may have been distorted by non-responses.

Inspection of Table 15 suggests no convincing relationship between bus trip rates and income, once car ownership has been allowed for. This is confirmed by regression analysis, both for individual areas (where samples are rather small) and for all areas (except Woodley[4]) taken together. We therefore make no further attempt in this report to consider income as an explanatory factor (except insofar as it affects car ownership).

2.5.3 Household size

Table 16 shows bus trip rates for people living in one-and two-person households. A much greater proportion (63 per cent) of two-person households own cars than do one-person households (21 per cent). Members of two-person households therefore tend to make fewer bus trips, but when the population is segregated by car ownership the effects of household size are much less apparent. The only significant differences are for non-car-owning concessionaires in Woodley, and for non-car-owners in Kingswood, with members of two-person households making fewer trips in the former case, but more in the latter.

To some extent the tendency of people in two-person car-owning households to make fewer bus trips may be countered by the use of cars for journeys by partners to and from work. However, examination of trip rates of the fairly small number of respondents with working partners reveals no clear indication of such an effect.

It is relatively easy to suggest explanations as to why bus use should be less (per person) in two-person households. For example, if one person can cope with the household shopping, then paying two bus fares or using twice as many tokens is an extravagance. In car owning households however, car availability, especially for non-drivers, may be affected by the use of cars by partners, and lead to greater bus use than in single person households. Our statistics are clearly insufficient to support either of these hypotheses, or the notion that household size is an important factor for any other reason. We therefore ignore household size in the subsequent analysis in this report.

Table 15 Weekly bus trip rates: effect of household income

Household income	*Tilehurst (conc)*		*Woodley (non conc)*		*Woodley*		*Fishponds*		*Kingswood*	
No car										
<£5000	6.54±0.64	(52)	4.22±0.52	(40)	3.57±1.11	(7)	4.42±0.49	(74)	5.55±0.57	(92)
£5000-£9999	7.44±0.89	(50)	3.00±0.55	(22)	3.06±0.93	(17)	2.55±0.47	(42)	5.15±0.80	(41)
£10000-£14999	3.50±0.50	(4)	2.00±1.15	(3)	2.00±1.15	(3)	4.86±2.51	(7)	3.20±2.24	(5)
≥£15000	5.00	(1)	-	(0)	-	(0)	0	(1)	2.00±1.55	(5)
na	7.76±0.70	(33)	2.81±0.54	(16)	3.27±1.12	(11)	5.06±0.76	(35)	5.41±0.87	(29)
All incomes	7.05±0.43	(140)	3.53±0.32	(81)	3.13±0.56	(38)	4.06±0.33	(159)	5.26±0.39	(172)
Car										
<£5000	4.58±0.85	(12)	2.47±0.51	(15)	0.67±0.67	(3)	1.72±0.73	(18)	2.16±0.52	(25)
£5000-£9999	4.70±0.62	(40)	1.84±0.42	(25)	1.54±0.40	(24)	1.84±0.47	(38)	3.03±0.65	(29)
£10000-£14999	4.71±0.83	(28)	1.25±0.48	(4)	1.09±0.31	(22)	0.44±0.29	(9)	1.18±0.42	(11)
≥£15000	3.40±0.59	(25)	-	(0)	0.85±0.38	(20)	0	(1)	2.56±0.78	(9)
na	4.08±0.65	(37)	3.22±1.71	(9)	1.21±0.33	(38)	2.00±0.53	(27)	3.00±0.67	(28)
All incomes	4.30±0.32	(142)	2.21±0.38	(53)	1.18±0.18	(107)	1.71±0.29	(93)	2.57±0.30	(102)

± indicates standard error of mean (not estimated for samples smaller than 3); ( ) indicates sample size

Table 16 Weekly bus trip rates: effect of household size

Persons in household	*Tilehurst*	*Woodley (conc)*	*Woodley (non conc)*	*Fishponds*	*Kingswood*
No car					
1	7.05±0.66 (75)	4.06±0.42 (53)	2.50±0.56 (26)	4.12±0.48 (78)	4.48±0.42 (100)
2	7.05±0.55 (65)	2.54±0.44 (28)	4.50±1.24 (12)	4.00±0.46 (81)	6.35±0.72 (72)
All households	7.05±0.43 (140)	3.53±0.32 (81)	3.13±0.56 (38)	4.06±0.33 (159)	5.26±0.39 (172)
Car					
1	5.64±1.03 (22)	3.43±1.11 (14)	1.35±0.52 (17)	1.89±0.86 (9)	1.67±0.50 (18)
2	4.06±0.32 (120)	1.77±0.31 (39)	1.14±0.19 (90)	1.69±0.31 (84)	2.76±0.35 (84)
All households	4.30±0.32 (142)	2.21±0.38 (53)	1.18±0.18 (107)	1.71±0.29 (93)	2.57±0.30 (102)

± indicates standard error of mean; ( ) indicates sample size

2.5.4 Age and sex

In Table 17 bus trip rates are shown separately for women under 65, and men and women 65 years old or more. Only 36 per cent of the older women are in car-owning households, compared with 59 per cent of the younger women and men. So it is again necessary to consider car owners and non-car owners separately to isolate any other effects. Among non-car owners, it might be expected that greater proportions of younger women would be capable of walking, and therefore make less use of buses. The statistics suggest that this may be so, but none of the observed differences are significant. In car-owning households, women, and especially older women, are more likely to have to rely on their partners to drive, and may therefore make less use of cars and more of buses. However, there is only one case (Kingswood) where there is a significant difference in the trip rates for men and women. On the basis of this evidence, age and sex must be discarded as explanatory factors.

2.6 Differences between areas

Having established that within each area the only quantifiable personal factor which significantly influences bus trip rates is household car ownership, we may proceed to compare trip rates between areas. These are summarised in Table 18 which shows bus trip rates for people with and without cars in all four study areas, with those in Woodley being divided into those with and without concessions (in the other three areas everyone in the appropriate age group is eligible).

This table shows a sharp contrast between elderly people in Tilehurst, who enjoy free bus travel, and those in Woodley who have to pay full fares. There is a lesser difference between those with and without concessions in Woodley, especially among car owners. The Fishponds and Kingswood results are roughly intermediate between those for Woodley and Tilehurst.

However, comparisons of this kind may well be over-simplistic: we cannot ignore the possibility that differences between areas in bus service characteristics or in general travel patterns may contribute to differences in trip rates. In this section we therefore consider such differences between areas, and attempt to gauge their importance.

2.6.1 Journey purposes

The proportions of journeys undertaken for the main purposes by respondents in each area are shown in Table 19. There is a remarkable similarity between all areas, except for a greater proportion of social or leisure trips in Woodley, possibly reflecting a greater degree of car

Table 17 Weekly bus trip rates: effect of age and sex

Age group/sex	*Tilehurst (conc)*	*Woodley (non conc)*	*Woodley*	*Fishponds*	*Kingswood*
No car					
60-64 F	6.40±0.85 (30)	3.58±1.04 (12)	2.20±0.71 (15)	3.26±0.48 (31)	5.33±0.80 (36)
65+ F	7.03±0.52 (70)	3.67±0.42 (46)	3.71±1.02 (14)	3.92±0.45 (84)	4.98±0.51 (87)
65+ M	7.58±1.04 (40)	3.22±0.57 (23)	3.78±1.31 (9)	4.89±0.75 (44)	5.71±0.88 (49)
All persons	7.05±0.43 (140)	3.53±0.32 (81)	3.13±0.56 (38)	4.06±0.33 (159)	5.26±0.39 (172)
Car					
60-64 F	4.87±0.55 (52)	2.00±0.58 (10)	1.26±0.30 (42)	1.20±0.49 (20)	3.45±0.64 (31)
65+ F	4.11±0.49 (38)	2.59±0.50 (17)	1.52±0.34 (27)	2.41±0.53 (32)	2.76±0.52 (34)
65+ M	3.88±0.57 (52)	2.04±0.67 (26)	0.84±0.28 (38)	1.41±0.44 (41)	1.65±0.39 (37)
All persons	4.30±0.32 (142)	2.21±0.38 (53)	1.18±0.18 (107)	1.71±0.29 (93)	2.57±0.30 (102)

± indicates standard error of mean; ( ) indicates sample size

Table 18 Bus trip rates by area and car ownership

	Tilehurst	*Woodley (conc)*	*Woodley (non conc)*	*Fishponds*	*Kingswood*
No car	7.05±0.43 (140)	3.53±0.32 (81)	3.13±0.56 (38)	4.06±0.33 (159)	5.26±0.39 (172)
Car	4.30±0.32 (142)	2.21±0.38 (53)	1.18±0.18 (107)	1.71±0.29 (93)	2.57±0.30 (102)

± indicates standard error of mean; ( ) indicates sample size

accessibility (see Table 6), and a few more work-related trips in Tilehurst and Woodley However, these differences appear too small to account for any significant variation in bus trip rates between areas.

Table 19 Journey purposes *(percentage of trips by all modes)*

Purpose	*Tilehurst*	*Woodley*	*Fishponds*	*Kingswood*
Return home	45.2	45.3	46.4	46.8
Shopping	21.8	20.4	22.3	20.9
Social/leisure	12.0	15.5	11.9	12.1
Visiting	8.3	7.2	8.6	8.6
Personal business	6.0	5.5	5.1	5.3
Medical	2.5	2.0	2.5	2.8
Work	2.4	2.4	0.9	1.5
Other/not stated	1.9	1.7	2.2	1.9
Sample size	4804	4853	3876	4290

2.6.2 Trip ends

Although it appears that respondents in each area travel for much the same kinds of purpose, differences in geographical disposition of their homes and the places they visit to fulfil their needs may contribute to variations in travel patterns and bus use. Proportions of trips between principal origins and destinations are shown in Table 20.

This table contains some interesting similarities, and some striking contrasts. In all cases, there are more trips by all modes within the local area than any other origin/ destination pair. However, the proportion of trips by all modes to the main town centres (Reading or Bristol) decreases markedly moving down the table from Tilehurst to Kingswood, and the pattern for car trips is similar. We can advance no reasons why Bristol should be intrinsically less attractive as an urban centre than Reading, but suggest that the difference lies in the scale and scope of alternative attractions. Kingswood, at least, has a commercial centre appropriate to a medium sized town, whereas facilities in Tilehurst and Woodley provide for the basic needs of more limited catchment areas. Kingswood also seems to act as a local attraction for Fishponds residents, who make more trips there than to central Bristol.

However, while trips by car generally outnumber trips by bus, the reverse holds for journeys between homes and urban centres: the difficulties of driving in urban traffic and parking may be amplified by age. In the Reading area, more bus trips are made to and from the town centre than anywhere else, but the bus:car ratio for Tilehurst is more than double that for Woodley. While it is arguable, in view of the difference in numbers of car trips, that Reading is more attractive to residents of Tilehurst, the additional attraction by virtue of free travel for all pensioners (and, as we shall discuss later, a higher service frequency for many) seems to accentuate the difference in travel patterns, and this effect must be regarded as an integral part of the process of trip generation.

Table 20 Location of trip ends

Tilehurst to/from:	*Tilehurst*	*Reading centre*	*Other Reading*		*All O/D*
by Bus	361 (22.1%)	1005 (61.6%)	73 (4.5%)		1632 (100%)
by Car	758 (42.0%)	260 (14.4%)	444 (24.6%)		1805 (100%)
by All modes	2325 (48.4%)	1278 (26.6%)	562 (11.7%)		4804 (100%)
Woodley to/from:	*Woodley*	*Reading centre*	*Other Reading*		*All O/D*
by Bus	117 (16.0%)	321 (45.7%)	67 (9.6%)		703 (100%)
by Car	765 (34.8%)	176 (8.0%)	736 (33.5%)		2198 (100%)
by All modes	2325 (48.0%)	518 (10.7%)	998 (20.6%)		4844 (100%)
Fishponds to/from:	*Fishponds*	*Bristol centre*	*Other Bristol*	*Kingswood*	*All O/D*
by Bus	172 (20.7%)	155 (18.6%)	172 (20.6%)	195 (23.4%)	833 (100%)
by Car	443 (28.5%)	73 (4.7%)	526 (33.9%)	201 (12.9%)	1553 (100%)
by All modes	1574 (40.6%)	233 (6.0%)	869 (22.4%)	592 (15.3%)	3876 (100%)
Kingswood to/from:	*Kingswood*	*Bristol centre*	*Other Bristol*	*Fishponds*	*All O/D*
by Bus	655 (55.6%)	146 (12.3%)	173 (14.7%)	49 (4.2%)	1176 (100%)
by Car	777 (45.0%)	47 (3.3%)	544 (31.5%)	103 (7.1%)	1725 (100%)
by All modes	2574 (60.0%)	215 (5%)	812 (18.9%)	192 (4.5%)	4290 (100%)

2.6.3 Service levels

Figures 1 and 2 give an indication of bus service levels in the four areas. Most residents of the Fishponds and Kingswood study areas live within reasonable walking distance of bus routes, with services operating at 10 minute intervals or less during the working day. In the Reading area spatial coverage of the route network is similar, but except for one route (route 17) running at 10 minute intervals in Tilehurst, which serves just under half of respondents in that area, typical service intervals are closer to 30 minutes.

It is a commonly held view that services operating at the higher frequencies are likely to attract more passengers, and that this possibility should be taken into account when comparing trip rates in the four areas. Accordingly, we have investigated the effect of service frequency in the Tilehurst study area, by using respondents' postcodes to determine distances from the 17 bus route. Table 21 gives bus trip rates for people living within 500 m of the route, and those living further away.

Table 21 Effect of service frequency

	Bus trip rates:		
Car ownership	*Respondents within 500m of route 17*	*Respondents further than 500m from route 17*	*All respondents**
No car	6.27±0.63 (56)	7.39±0.67 (69)	7.05±0.43 (140)
Car	4.49±0.66 (45)	4.33±0.39 (85)	4.30±0.32 (142)

* *including respondents with unidentifiable postcodes*

Neither of the apparent differences in trip rates between those living near the frequent bus service and others, for car owners and non-car owners, is statistically significant, suggesting that elderly people in Tilehurst are not sensitive to bus service frequency, at least over the range obtaining here. This finding is apparently at odds with generally accepted notions of service level elasticities (see for example (Bly and Webster 1980), but there are severe methodological difficulties in establishing such elasticities with any confidence, and few if any studies have made separate estimates for elderly people. It is likely that elderly people have lower values of time than other bus users, and so might be influenced less by service frequency. Further, as we have seen, most of our respondents have resided in the study areas for many years, and would have been reasonably familiar with the timings of buses they used regularly. Those using less frequent bus services would therefore be likely to plan journeys so as to arrive at bus stops just before the buses, ensuring that their waiting times were comparable with those of people using more frequent services.

Since we have found no evidence that Tilehurst respondents are affected by service frequency, it appears that there is no reason to suppose that differences in trip rates observed in the four study areas (where frequencies are broadly within the range offered in Tilehurst) are dependent on differences in service levels. This factor is therefore excluded from subsequent discussion.

2.6.4 Fare levels

The immediate effect of concessionary fare schemes is to modify the fares payable by concessionaires, so in making comparisons between schemes it is necessary to take into account differences in normal fares (ie fare paid by non-concessionary passengers) and in the concessions offered. In this section we first describe non-concessionary fares, then the concessions available in the four areas, then try to establish representative effective fares.

As we have seen, people use buses for a variety of journey purposes (which are much the same in each of our study areas) and to go to a wide range of destinations, with significant differences in travel patterns between areas. In order to compare fares, we have estimated the average of full adult fares for the types of bus journeys actually made by elderly people.

In three areas the survey provided information on full fares. Some people in Woodley actually paid full fares, so these are recorded. For those who used tokens, in Woodley and Kingswood, values of the tokens tendered, together with any cash payments, were recorded, giving full fares. In Fishponds the concession is a fare reduction of one third, so the full fare is readily calculated from the amount actually paid. In all three areas, the averages of such full fares were estimated for all the journeys of each of the common types. These are shown in Table 22.

There was no direct information available for Tilehurst, as concessionaires there paid no fares. Samples of journeys of each of the common types were drawn, and the full fare for each was determined by reference to fare tables. The resulting averages are also shown in Table 22.

The mean fares, shown in the last column of Table 22 have been weighted in proportion to the numbers of journeys of each type, shown in Table 20. The resulting differences therefore reflect differences between the areas in both fare levels and patterns of bus journeys.

These factors inevitably complicate any comparison of

Table 22 Average full fares for main types of journeys (p)

	Tilehurst	*Reading centre*	*Other Reading*		*Mean fare*
Tilehurst to/from:	55	76	83		71.1
Woodley to/from:	40	91	77		77.4
	Fishponds	*Bristol centre*	*Other Bristol*	*Kingswood*	*Mean fare*
Fishponds to/from:	36	72	66	51	55.7
Kingswood to/from:	44	81	78	51	55.3

the effects of concessions between Avon and Berkshire, but do not necessarily invalidate it. This point is discussed further in due course.

2.6.5 Concessions

It is now necessary to consider how the mean full fares just estimated are modified by the various concessionary fare schemes in operation. The simplest cases are those in Tilehurst, where those who qualify travel on buses free (ie at zero fares), and for non-qualifiers in Woodley, who have to pay full fares. The Fishponds case is also straightforward: concessionaires simply pay two thirds of the full fares.

But where, as in Kingswood and Woodley, concessions take the form of tokens which are used for paying fares as if they were cash, it is less clear how people might perceive fares. One extreme view is that people treat tokens exactly as if they were money, and spend them with equal care. It would therefore make no difference whether a fare is paid with cash or tokens, and there would be no perceived fare reduction.

Another extreme view is that while people have a supply of tokens, they can use buses without paying real money, and so regard bus travel as free. However, once they have run out of tokens, they have to pay the full fare, and behave as if there were no concession. This might lead to the expectation that bus trip rates would be lower among people who had used all their tokens than among others, but, as Table 23 indicates, the limited evidence available from this study does not fit this hypothesis. In Woodley the difference in trip rates is not statistically significant, but in Kingswood, the people who have run out of tokens make substantially more bus trips than the others. The explanation seems to be that those who make more frequent use of buses run out of tokens first, but continue to use buses at a more frequent rate than their more frugal counterparts.

Table 23 Bus trip rates by concessionaires with and without tokens

	People still with tokens	*People with no tokens left*
Woodley	2.90±0.25 (114)	3.60±0.87 (20)
Kingswood	3.42±0.24 (219)	7.58±0.91 (55)

A third possibility is that people generally attempt to husband their supply of tokens, perhaps supplementing them with cash where necessary, so as to make them last throughout the year. The effective fare reduction would be the annual value of tokens (assuming no residue from the previous year) divided by the mean annual number of bus trips. While this argument provides a means of interpolating between the two extreme views set out above, it is subject to the following qualifications:

we cannot accurately compute mean annual trip rates: there may well be seasonal variations, with more bus journeys in summer than in winter, and the trip rates observed in the September surveys do not necessarily represent the average over the year;

the argument does not hold either for more frequent bus users, who run out of tokens early, or less frequent users who finish the year with a residue of tokens; those in the former category benefit from a lower than average fare reduction, and *vice versa;*

there may also be some people who behave in accordance with the more extreme views set out above.

To make quantitative estimates of these effects would require much more detailed information about individuals and attitudes than could be obtained within the limitations of this study, and it is doubtful whether a more expensive, psychologically focused survey would really resolve these issues. As a working hypothesis, we have made the supposition that the more extreme effects may tend to cancel each other out: we have divided annual token values by observed trip rates to yield effective fare reductions and thence effective concessionary fares, which should be taken as central estimates subject to a wide margin of error.

The resulting effective mean fares, computed as described here for people using tokens, and more simply for other types of concession, are shown in Table 24. Separate estimates are made for car-owning households and others in the token areas, since average trip rates are lower for car owners, and consequently the average fare reductions are greater.

Table 24 Effective concessionary fares

	Weekly trip rate	*Mean full fare*[1]	*Annual value of tokens*	*Effective discount*[2]	*Effective fare*
No car					
Kingswood	5.26	55.3p	£31	11.8p	43.5p
Fishponds	4.06	55.7p	..	18.6p	37.1p
Tilehurst	7.05	71.1p	..	71.1p	0
Woodley (qualifiers)	3.53	77.3p	£68	38.5p	38.8p
Woodley (non-qualifiers)	3.13	77.3p	..	0	77.3p
Car					
Kingswood	2.57	55.3p	£31	24.1p	31.2p
Fishponds	1.71	55.7p	..	18.6p	37.1p
Tilehurst	4.30	71.1p	..	71.1p	0
Woodley (qualifiers)	2.21	77.3p	£68	61.5p	15.8p
Woodley (non-qualifiers)	1.18	77.3p	..	0	77.3p

[1]From table [22]. Although mean fares actually paid by people with and without cars may be different, because of differences in patterns of bus use, the same services at the same fares are available to both groups, so no distinction is made here.

[2]In Kingswood and Woodley, the effective discount for people with tokens, is the annual token value divided by the mean annual trip rate, which is taken to be the observed weekly trip rate multiplied by 50. In Fishponds the discount is one third of the full fare, and in Tilehurst it is equal to the full fare. There is no discount for non-qualifiers in Woodley .

2.7 Demand functions

The effective fares and the corresponding bus trip rates are plotted in Figure 3 for no car households, and in Figure 4 for households with cars. In each case the trip rate is shown by a vertical bar as a range extending by one standard error above and below the observed mean value. As indicated in the previous section, uncertainties in effective fares, especially where concessions take the form of tokens, cannot be estimated and are not shown; for the same reason we have excluded the data for token schemes in fitting demand functions.

Having considered a variety of possible demand functions, two commonly used forms of function have been fitted. The first is the simple exponential form:

$$n(f) = n(0)\exp(\alpha f) \qquad (4)$$

where $n(f)$ is the trip rate at mean fare f, and $n(0)$ and α are constants to be determined. The elasticity with respect to fare is αf, and increases with fare. In our case we have three pairs of observations[5], and it is not possible to find two constants to give a perfect fit. The best fit, obtained by a least squares fitting method, is shown by a dashed curve for no car households in Figure 3, and for households with cars in Figure 4.

The second functional form is that corresponding to a constant elasticity with respect to generalised cost:

$$n(f) = n(0)(1 + f/c)^{\varepsilon} \qquad (5)$$

where $n(f)$ is the trip rate at mean fare f, c is the non-monetary part of the generalised cost, representing the value of riding, walking and waiting time, and any other relevant factors[6], and ε is the constant elasticity. Since there are three constants to be determined, and three pairs of observations, all three can be determined uniquely, giving a perfect fit, which is shown as a dotted curve in Figures 3 and 4 for households without and with cars.

The differences between the two functions are not substantially greater than the uncertainties in the observations, so that either could be used to describe our results. The constant elasticity curve is, necessarily a better fit by virtue of its additional parameter, the constant c which takes the value of 16.2p for households without cars, and 10.3p for those with cars. This seems to imply a very low value of time, perhaps of the order of ½p per minute assuming an average journey time, including waiting, walking and riding, of about 20 minutes. The higher value for carless people perhaps reflects their inability to use cars for journeys which are less convenient by bus.

The trip rates in Kingswood seem anomalously high compared with the other areas, for both car owners and others. This may well be due to miscalculation of the effective fare: the assumption that people spread their use of tokens evenly throughout the year may not apply to Kingswood pensioners. We can advance no explanation of why Kingswood and Woodley residents should differ in this respect. The constant elasticity curves seem to fit the Woodley results reasonably well.

It is important to stress at this point that the fares and trip rates shown in Figures 3 and 4 represent averages over all trips in each area. Research on much larger data sets (Balcombe and Astrop 1995, and later work by MVA described later in this report) suggests that elasticities may vary with trip length or fare level, but our sample sizes are to small to disaggregate the data in this way and produce statistically significant results. However, since the respondents in our four study areas made broadly comparable numbers of journeys by all modes, and travelled for very much the same purposes, it is arguable that differences in average trip rates are a general reflection of differences in fare levels, whether these be caused by geographical differences (for example, some areas are more remote from major shopping centres),

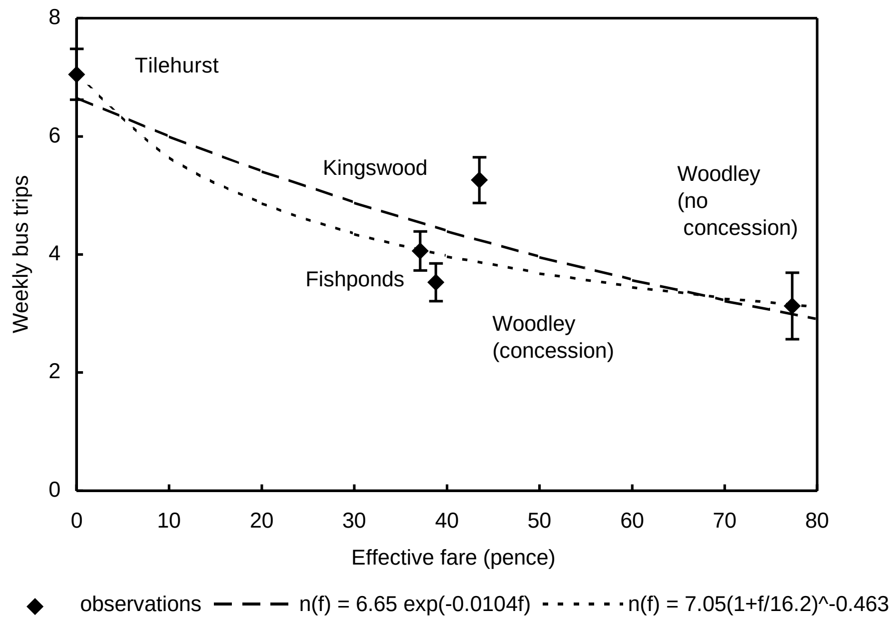


Figure 3 Demand for buses (no car households)

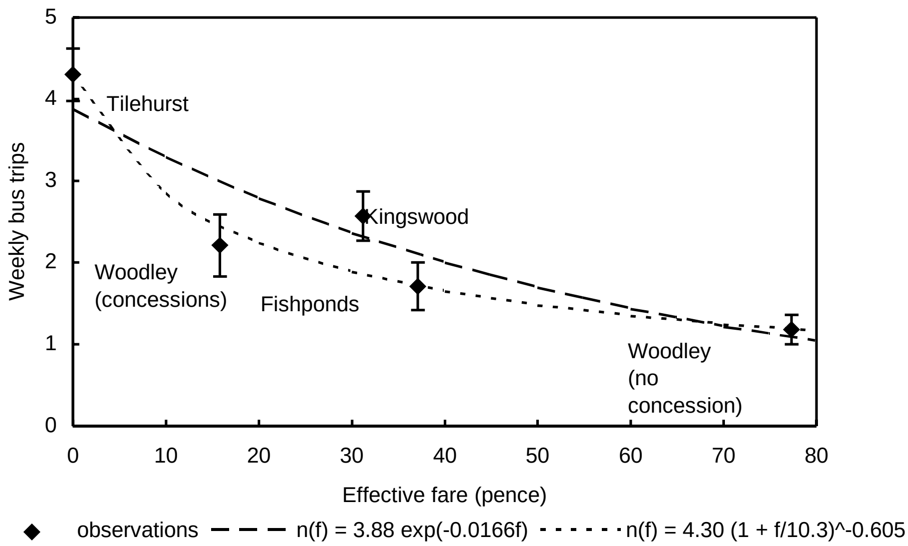


Figure 4 Demand for buses (households with cars)

differences in general fare levels, or differences in concessions. There is no reason to suppose that a typical Fishponds pensioner, if transplanted to Tilehurst, would not behave like a typical Tilehurst pensioner. So that if fares in Fishponds were adjusted to the Tilehurst level, then trip rates would change accordingly.

The generalised cost elasticities implied by the constant elasticity functions in Figures 3 and 4 are -0.46 for non car owners, and -0.60 for car owners. The corresponding fare elasticities[7] are -0.35 and -0.50 at an average full fare of 50p, and -0.38 and -0.53 at 75p. These are higher than average fare elasticities for bus passengers generally, but are not inconsistent with the range indicated for elderly people by Bly and Webster (1980): elderly passengers, many of whose journeys are for discretionary purposes, are likely to be more sensitive to fare levels than others. It is also reasonable to suppose that car owners, who have readier access to alternative transport, would be more sensitive to bus fares.

It is interesting to compare the results of this study with observations made in Tyne and Wear (Balcombe and Astrop 1995) in 1990, when concessionaires travelled free, and 1993 when they were charged a flat fare of 15p. The demand functions shown in Figures 3 and 4 would suggest that this change should have reduced demand by 26 per cent for people without cars, and 42 per cent for those with cars. No information on car ownership was collected in Tyne and Wear, but it is likely that the a large majority of elderly bus passengers there do not own cars, so that the overall reduction would be closer to 26 than 42 per cent. The observed change was a reduction of 25.5 per cent, from about 7.7 trips per person per week, but it was suggested that long-term trends would have produced a six per cent decline in demand over this period even if there had been no fare change. However, decline in demand in Tyne and Wear continued after the 1993 survey, so the longer-term effect of the fare change may not have been inconsistent with the findings of this study.

However, it would be imprudent at this stage to propose that the demand functions derived from this study should be applied universally. The possibility that there may be important differences between the elderly residents of Tilehurst and Woodley, and those of the Berkshire and Avon areas should not be ignored, even though we have been unable to discover any that seem to affect bus use, except for car ownership levels which we have taken into account. We may have been unable to identify or quantify differences between our study areas in factors which influence bus use. If so there may be larger differences between the study areas and other areas around the country.

We must also accept the possibility that our samples may have been too small to reveal real dependencies on factors like bus service frequencies. Extending the study to substantially larger samples, even if resources could be made available, may not be a practical proposition, since there are few pairs of areas which fit the necessary criteria. However, other large (but less detailed) data sources are available, and provide alternative methods of addressing the problem. These are discussed in the next two major sections of this report, and then the results of all three methods are compared.

3 Analysis of National Travel Survey data

3.1 The data base

3.1.1 National Travel Survey

The National Travel Survey (NTS) is designed to provide a national data bank of personal travel information for Great Britain. It consists of surveys of households, randomly selected within an overall sampling framework to ensure proper representation of all types of households and areas. Members of selected households are asked for personal information (eg age, sex, working status and driving licence holding) and details of travel made over seven consecutive days.

Previous surveys were carried out over twelve-month periods in 1965, 1972/73, 1975/76. 1978/79 and 1985/86.

In 1989 the approach was modified, by running the survey on a continuous basis, with fewer households being recruited in each year, but extending the survey over a number of consecutive years. Some 10000 households took part between January 1989 and December 1991, and a further 10000 between January 1992 and December 1994. The principal results from these surveys are reported by the Department of Transport (1993 and 1995).

Data from earlier National Travel Surveys have been studied in previous TRL research on concessionary fares (Hopkin 1986, O'Reilly 1990). This study has made use of data from the surveys conducted between 1989 and 1994.

3.1.2 Data selection

A sub-set of the data was made available to TRL for the purposes of this study. Our principal concern was to compare frequencies of public transport use by people who qualify for concessionary travel, and similar people who do not. This immediately presents a statistical difficulty, as qualifiers are generally older than non-qualifiers, and less likely to be in employment. We therefore decided to examine public transport use of the group of non-qualifying NTS respondents who were closest in age to those qualifying for concessions, and to control for differences in employment status and other relevant factors. There were nearly 18000 individuals, from nearly 12000 households, in this data sub-set.

However, the studies of matched pairs of areas (section 2.3.1) showed that between 88 and 92 per cent of people old enough to qualify for concessionary travel lived in one- or two-person households. There were too few in larger households to provide large enough samples for separate analysis of their travel habits, and to determine whether their use of public transport differed from those of the majority. Accordingly, only members of one-or two-person households were included in the analysis. In this part of the study we have also limited our attention to one- or two-person households for similar reasons, and to provide as much compatibility as possible between the two parts of the work. This reduces the size of the data base to 14182 individuals, from 9730 households (5285 with one member, 4445 with two). Almost exactly two thirds of these respondents were of pensionable age (men 60+, women 65+), and, in most areas, would qualify for concessionary travel.

3.1.3 Personal and household characteristics

The distributions of this sample over different age groups, sexes, employment status and car ownership are summarised in Table 25.

Table 25 shows that women outnumber men in every age group in the sample, but that the smallest age group, males between 50 and 54 years old, appears to be sufficiently large (726) for robust statistical analysis. However, when the age groups are subdivided according to employment status, car ownership and other factors to be considered later, cell sizes become much smaller, and it is necessary to exercise considerable judgement as to which variables are worth inclusion in statistical analysis.

Table 25 Age, employment status and car ownership

	Percentage of age group:				
Age group	*Respon -dents in age group (%)*	*Emp -loyed full time*	*Emp -loyed part time*	*Not emp -loyed*	*With house -hold car*
Females					
50-54	11	35.6	30.4	34.0	79
55-59	13	26.4	28.6	45.0	73
60-64	16	7.0	11.8	81.2	66
65-69	18	1.6	5.6	92.8	52
70-74	15	0.4	3.0	96.6	39
75+	27	0.3	0.6	99.1	20
All ages	100 (N=8110)	9.1	10.8	80.1	50
Males					
50-54	12	77.9	2.1	20.0	81
55-59	16	63.9	3.9	32.8	79
60-64	17	37.0	5.0	58.0	74
65-69	20	4.2	8.0	87.8	70
70-74	15	1.1	6.3	92.6	59
75+	20	0.9	2.4	96.7	42
All ages	100 (N=6064)	26.8	4.7	68.4	66

As expected, Table 25 shows clear dependencies of employment status and car ownership on age, and on sex. People in full time employment are likely to make more journeys than others, since they travel to and from more, but they are also more likely to use cars. Car ownership and employment status therefore need careful investigation as explanators of public transport use.

Table 26, which shows the distribution of household incomes over the sample, is disappointing in that over half the respondents refused or were unable to state their household incomes. This is a much higher proportion than was found in the study of matched areas (section 2.3.2), where the refusal rate produced doubts about the accuracy and representativeness of those income estimates that were given. In that study, however, it was found that once car ownership had been taken into account, income level was not a significant explanator of public transport use. In view of the high refusal rate in the NTS sample, income levels are not included in the statistical analyses in this study.

Table 26 Household income

Income band	*Proportion of respondents*
Less than £5000	15%
£5000-7999	11%
£8000-9999	4%
£10000-14999	6%
£15000-19999	4%
£20000+	6%
Not stated	55%
Total cases	9730

Almost exactly one half (50.1 per cent) of households in the sample did not own cars. There was a concentration of cars in two-person households, which accounts for the higher proportions of individuals (50 per cent of women, 66 per cent of men, Table 25) in car-owning households.

3.1.4 Bus services

Table 27 summarises two important features of bus services available to respondents: walking time to stops and service frequencies. Some 95 per cent of households in the sample are situated within 13 minutes walk of a bus stop, and some 65 per cent are served by buses at least twice an hour; only 10 percent are served less than hourly. A substantial proportion of respondents appeared to be unaware of local bus service frequencies, suggesting that these people use buses rarely, if at all.

Table 27 Bus services: walk time to nearest stop and frequencies

Walking time (minutes)	*Households (per cent)*	*Service frequency*	*Households (per cent)*
< 3	54.7%	less than daily	1.9%
4-6	30.0%	more than daily, less than hourly	8.1%
7-13	11.2%	at least hourly, less than 2/h	14.0%
14-26	2.3%	at least 2/h, less than 4/h	33.3%
27-43	0.5%	at least 4/h	32.4%
44 +	0.4%		
Not stated	0.9%	not stated	10.3%
	N=9730		N=9730

3.1.5 Concessionary fare schemes

All parts of Great Britain were included in the NTS, so that respondents potentially qualified for a wide variety of concessionary fare schemes. The distribution of people of pensionable age between areas with different categories of scheme is shown in Table 28, together with similar estimates based on a survey by TAS of local authorities (Huntley et al 1995).

Table 28 People of pensionable age

Type of concession	*NTS (1989-94)*	*TAS (1995)*
Free travel	22%	21%
Flat fare	11%	17%
Half fare	27%	35%
Two-thirds fare	3%	2%
Tokens	13%	13%
Other/mixed	20%	10%
None	5%	2%
Not known	5%	0%

While there is broad agreement between the two distributions, the differences are great enough to merit comment. The most obvious cause of discrepancy is that the TAS survey provides a ‘snapshot’ of the 1995 situation, whereas the NTS was conducted over six years, during which time there were some substantial changes in concessionary fare schemes (eg in Tyne and Wear and Lothian, where free travel was replaced by flat fares). Significant numbers of people did not appear to know what types of concession were available to them; it is likely that others may have answered incorrectly. The responses of some local authorities to the TAS surveys were ambiguous, or missing, but in view of the number of such cases it is unlikely that the resulting estimates shown in Table 28 are significantly in error.

The criteria for qualification for concessionary travel, and the fees levied for issuing passes or tokens, are shown in Table 29. Substantial numbers of respondents were unable to indicate either the qualifying conditions or the entry fees in their areas; presumably most of these were non-bus users or were less than 60 years old, and so would have had no direct involvement with concessions. The overwhelming majority of households which responded were in areas where being of pensionable age (60+ for women, 65+ for men) was the only, or main qualification. Over half the households were in areas where no entry fee was charged, and only two to four per cent in areas where the fee exceeded fifteen pounds[8]. If the non-responses are discounted, 61 per cent of households are in areas where no entry fees are charged.

Table 29 Eligibility for concessions, and fees

Eligibility condition	*House -holds*	*Partici -pation fee*	*House -holds*
Pensionable age	78.2%	None	52.4%
65+	0.8%	up to £5	18.5%
Pensionable age and receiving pension	1.5%	£5.01-£10	7.9%
Pensionable age + income restriction	3.2%	£10.01-£15	3.1%
Other condition	5.5%	£15+	1.5%
		other	2.5%
NA/don’t know	10.8%	not stated	14.1%
	N=9730		N=9370

Nevertheless, only 62 per cent of women aged 60 or more, and 55 per cent of men aged 65 or more, were found to be concessionary pass holders, or to have been issued with concessionary tokens. This contrasts with our local studies (section 2.3.2) in which around 90 per cent of the bus users eligible for concessions took advantage of them. The explanation is that the local study samples were recruited from regular or occasional bus users (ie those who had travelled by bus at least once in the previous six months), whereas the randomly selected NTS samples must contain significant proportions of people who rarely or never use buses.

3.1.6 Trip rates

For each respondent, the public transport trip rate was taken as the number of stages travelled by any of the main forms of bus or rail (including underground and tramway systems) during the seven consecutive days recorded in the travel diary. This may overstate the number of trips involving the use of public transport, but since there are relatively few multi-stage trips (see Balcombe and Astrop 1995) the discrepancy is too small to justify the additional effort of condensing the data and the consequent complications in analysis. For each sub-group of people considered in this report, the average trip rate is the weighted mean over all members of the sub-group.

3.1.7 Fares

In order to understand how concessions affect trip rates it is necessary to be able to compare fares paid by concessionaires with the fares they would pay if no concessions were available. While this is simple in principle, there are complications in practice. Fares depend on trip lengths, operators, and where season tickets and travelcards are in use the concept of a fare for a particular journey is of dubious validity. In this study we have therefore adopted the device of comparing ordinary adult fares[9] paid by non-concessionaires with actual concessionary fares. For each sub-group this involves averaging over all trips, and over all areas.

Concessionary tokens present a particular problem, since fares may be made with a mixture of cash and tokens, and people may have different attitudes to tokens, with some treating them as if they were cash, and others regarding them as a free resource (section 2.6.5). Another complication is that there is considerable variation in the annual value of tokens issued, so token holders are a very heterogeneous sub-group, which cannot usefully be sub-divided by token value bands because sample sizes become unacceptably small. In this study we have reluctantly decided to exclude token holders, on whom only about five per cent of the national concessionary fare budget is spent[10].

Similarly we have excluded schemes which offer discounts of one third of full fares, since the sample sizes are too small for useful analysis (see Table 28), and schemes which offer ‘other reduced’ fares or other or mixed concessions, as these are largely unspecified and form a very heterogeneous set.

Our main concern is therefore with schemes which offer free travel, flat fares, or half fares. The average values of such fares, over all appropriate areas, are compared with average full adult fares in Table 30.

Table 30 Average fares

	Type of concession		
	Free travel	*Flat fare*	*Half fare*
Average concessionary fare	0	19.6p	31.1p
Average adult fare	62.0p	57.2p	63.6p

These averages apply to all respondents in the three types of areas. Where the sample is subdivided into smaller groups (eg by car ownership) separate averages are estimated. They differ from those shown in the table by relatively small amounts.

3.2 Analysis of trip rates

Research on matched pairs of areas (section 2.5) found that the most important determinant of public transport use was car ownership. Once this was taken into account, factors like age, sex, and income had no statistically significant effect. However, the overall sample size from the NTS is considerably greater than that in the local studies, so these factors are worthy of re-examination, together with others, like employment status, which was heavily biased towards not employed.

3.2.1 Age

Figures 5 and 6 show plots of trip rates against age group for women and men, with and without household cars, employed and not employed, in free, flat fare and half fare concession areas. Visual analysis is difficult where there are so many dimensions, and can be misleading when, as in this case, some of the points plotted are derived from very small samples (for example, most subgroups of employed people 70 or more years old contain fewer than 10 individuals, in some case as low a one or even zero). However, while taking heed of this caveat, it is possible to discern some plausible relationships which should be worthy of exploration using more rigorous methods.

The figures suggest that:

1 people without cars make more trips than people with cars;

2 employed people make more trips than those who are not employed;

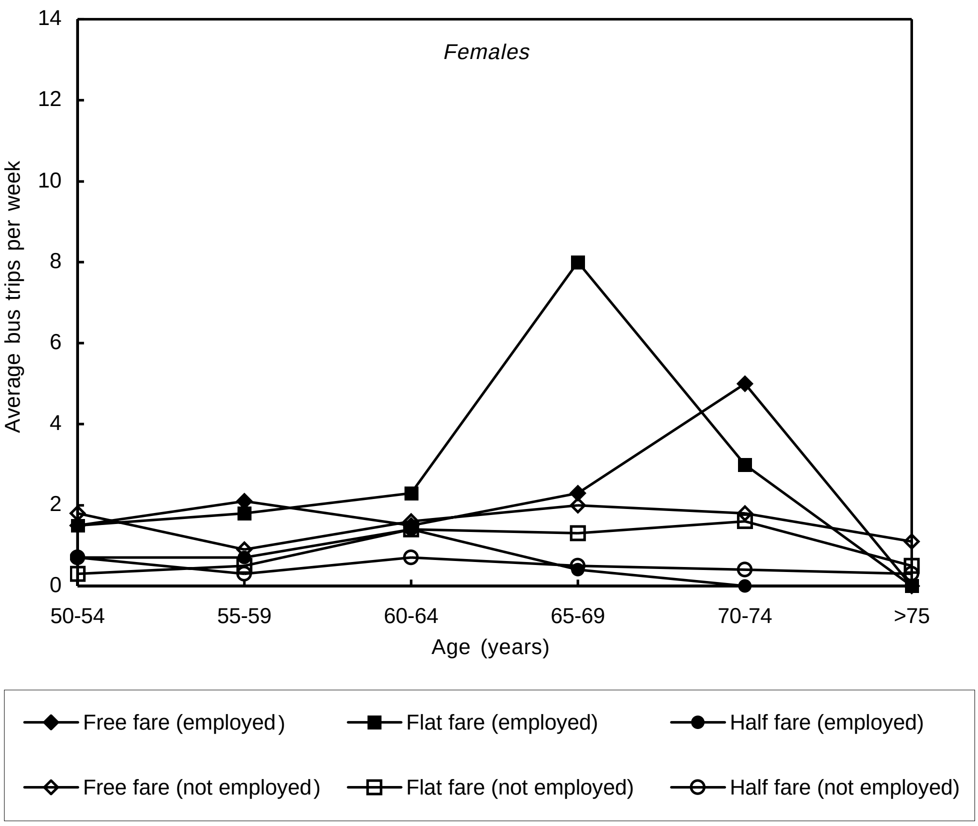
3 trip rates for women without cars and not in employment tends to increase when they reach the qualifying age for concessions (60), especially in free and flat fare areas; any corresponding result for employed women may be illusory because of the tiny sample sizes above 64 years of age;

4 there is no obvious change in trip rates for men without cars, whether employed or not, as they reach the qualifying age for concessions (65);

5 there is no obvious variation in trip rates with age for people of either sex with cars.

This is not to say that age is unimportant in determining trip rates, but that its influence is indirect through, for example, car ownership or employment status which, as we have seen (Table 25) are strongly dependent on age. It is to be expected that as people age they may progressively lose the ability to use public transport, but this effect would appear to be too weak to manifest in our limited data set, given the influence of stronger factors.

It therefore appears that there is nothing to be lost by ignoring age (except in so far as it qualifies people for concessionary travel) in further analysis, but there are two advantages to be gained: aggregating ages produces larger samples, or allows samples to be subdivided by other factors; and people under the qualifying ages can be regarded as a valid control group for those with concessions (given similar car ownership, employment status etc).



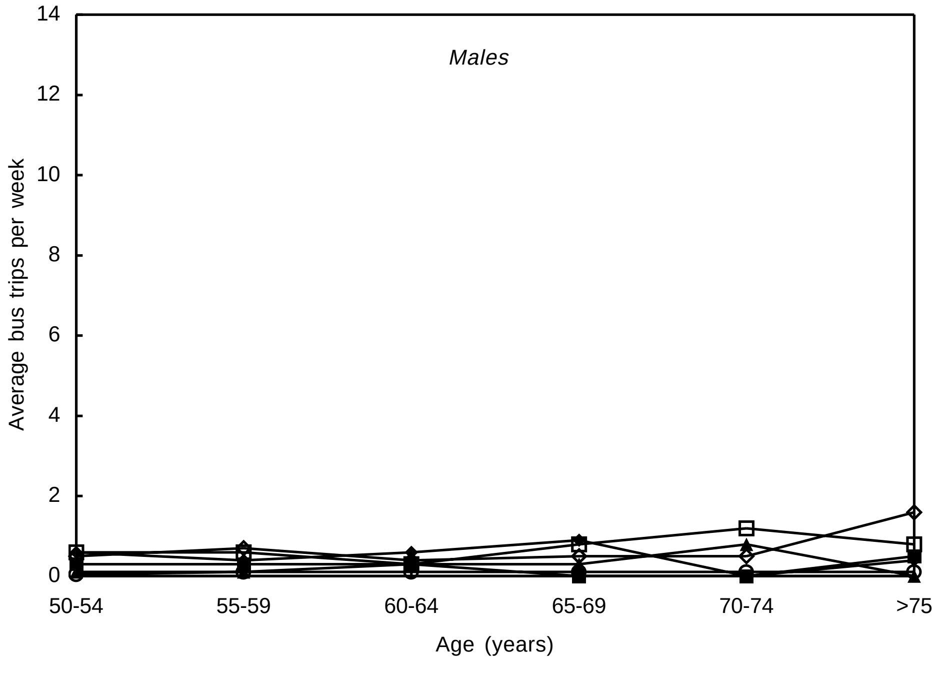


Figure 5 Bus trip rate by age and working status: car owners

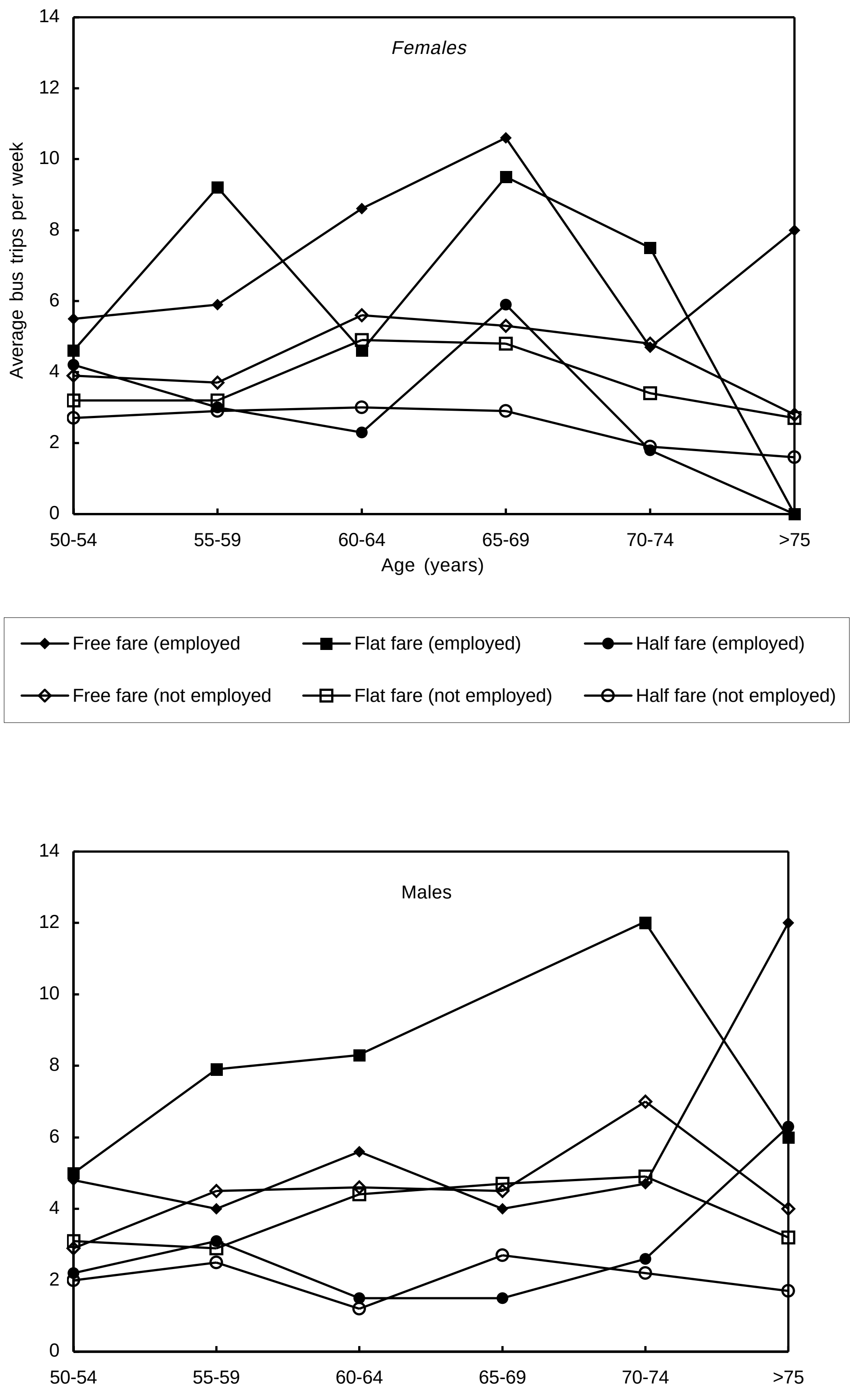


Figure 6 Bus trip rate by age and working status: non car owners

3.2.2 Other factors

Having discarded age as an explanatory variable, we are left with three of the variables considered in section 3.2.1 (car ownership, employment status and sex). We can represent the effect of concessions by assigning appropriate average fares according to the type of scheme) for those above and below the qualifying ages. We can also examine the effect of bus service frequency, which is normally regarded as being important in generating demand. The NTS bands service frequency into five ranges (see Table 27), but this produces very small samples with less than hourly services. Accordingly we have considered only three frequency bands: at least hourly, less than two per hour: at least two, less than four per hour; and at least four per hour. The number of values that can be taken by each variable is shown in Table 31.

Table 31 Factors used in trip rate analysis

Variable	*Possible values*	*Number of values*
SEX	0 (female),1 (male)	2
CAR	0 (no), 1 (yes)	2
EMP	0 (not employed), 1 (employed)	2
FREQ	1, 2, 4	3
FARE	concessionary, standard	2

This framework provides 48 subgroups in each of the three types of area (free travel, flat fare, half fare) making a total of 144, each with its own trip rate. There are now too many dimensions for visual analysis, so we resort to the usual method of regression analysis, treating sex, car ownership and employment status as binary variables, and bus frequency and fare as numeric variables.

We have also included ten compound variables (ie products of all possible pairs or triplets of the variables SEX, CAR, EMP, and FARE) to test for interactions between these factors.

Table 32 lists those variables which were shown by the regression analysis significantly to affect trip rates, the resulting coefficients and their standard errors and significance levels.

All the variables shown were highly significant (at the 0.01 per cent confidence level or better) but so too were a number of other compound variables. However, coefficients for these other variables had counter-intuitive signs (for example CAR*FARE had a positive coefficient, suggesting that people with cars who have to pay higher fares are likely to make more bus trips), and produced only very small improvements to the overall fit (R^2).

The coefficients for the simple variables all have intuitively correct signs: trip rates would be expected to be greater for people in employment, smaller for those with cars, and to vary with frequency or service level, but inversely with fare levels. Only one compound variable was retained in the model: the product of CAR and EMP. This indicates a strong interaction between car ownership and employment, perhaps suggesting that employed people with cars tend to use them for trips to and from work, and most other trips, whereas non-employed car owners may make some use of public transport for some trips (eg to town centres where parking may be difficult or expensive, see section 2.6.2).

The fare coefficient of -0.019 implies that average trip rates for people who have to pay full fares of around 60 pence are some 1.2 trips per week lower than for people with similar car ownership and employment status, but who enjoy free concessionary travel. This indicates that fare reductions through concessions are likely to affect trip rates, but not as much as car ownership or employment status.

One variable, SEX, is conspicuous by its absence in Table 32. At first sight this seems counter-intuitive, since all the evidence points to greater use of buses by women than by men. However, the relationships between employment status, car ownership and sex are so strong (Table 1) that once these factors are taken into account, there is no significant residual differences between the sexes.

The coefficients derived for the two models are remarkably similar, except for frequency or service level, so there is little indication in Table 32 as to which model is to be preferred.

Examination of residuals (differences between observed and predicted trip rates) for model A suggests no systematic deviation from zero, providing no evidence that the implicit assumption that trip rates vary linearly with service frequency (up to 4 per hour) is seriously flawed. However in view of our limited information on frequencies which compels us to use a variable with only three possible values, this assumption of linearity must be treated with caution. It should also be borne in mind that service frequency and demand are interdependent: where demand is high, for other reasons, operators will tend to run more buses, and vice versa.

Table 32 Regression analysis of trip rates

	Model A		*Model B*	
Variable	*Coefficient*	*Standard error of coefficient*	*Coefficient*	*Standard error of coefficient*
CONSTANT	3.145	0.232	3.241	0.238
CAR	-2.537	0.169	-2.568	0.171
EMP	2.417	0.347	2.444	0.353
CAR*EMP	-1.877	0.395	-1.880	0.403
FARE	-0.0193	0.0035	-0.0199	0.0036
FREQ	0.304	0.063	na	na
SERVL	na	na	0.887	0.212
R^2	0.787		0.779	

In our study of matched areas (section 2.6.3) there was no evidence that people in Tilehurst served by six buses per hour used them more than people served half-hourly, although according to model A the difference in trip rates would be some 1.2 trips per week.

Model B has therefore been considered to explore the possibility that trip rates may depend in a non-linear way on service frequency, with little variation above two bus per hour (as in Tilehurst), but possibly lower trip rates for less frequent services. Again, we have found no evidence to contradict this assumption, but the quality of the data prevent our concluding that it is necessarily valid.

Both models predict that for similar groups of people, those served by high frequency buses (four per hour or more) will make about 0.9 trips per week more than of people served by only one bus per hour. But the corresponding differences between people with half-hourly and hourly buses are 0.3 and 0.9 trips per week for models A and B respectively.

Since there is no obvious way of resolving this dilemma, we shall retain both models in subsequent analysis in this report, and try to exercise judgement when considering the implications.

Examination of residuals as a function of fare provides no evidence of non-linearity with respect to fare.

3.3 Estimation of trip rates

The results of the analysis in section 3.2.2 give an indication of which factors are significant in determining bus trip rates, and their relative importance. In effect, those shown in Table 8 account for some 80 per cent of the observed variation, and should therefore be reasonably useful in estimating how trip rates might be affected by variations in concessionary fare schemes.

In order to make such an estimate for a particular area, it would be necessary first to categorise the relevant population (eg women aged 60+, men aged 65+) by sex, employment status, car ownership and local bus service frequency. In practice it may not be possible to obtain appropriate statistics without undertaking a major survey, but reasonable approximations might be obtained using national and local sources of statistics and local knowledge.

Having thus segmented the population, there are two methods of proceeding with the calculation. The first is simply to consider pairs of segments, with each pair being composed of people with identical characteristics (car ownership, employment status etc) save for eligibility for public transport concessions. Those eligible will normally make more trips, and it is assumed that if concessions were not available, members of both segments would make trips at the rate now observed for those without concessions. These trip rates can then be weighted in proportion to the size of each segment, to give overall average trip rates. Table 33 shows the results of such calculations for three sub-groups of our NTS database, divided according to whether free, flat or half fare concessions are offered.

The first two trip rates shown in Table 33 (for non-qualifiers and qualifiers with actual concessions) are those derived directly from the NTS sample. The next trip rate (qualifiers without concessions) is derived by segmental comparison. This trip rate exceeds that for non-qualifiers, because the composition of the qualifying sample is different, containing for example smaller proportions of car owners and employed people. The generation factor is the ratio of trip rates for qualifiers with current concessions to their trip rates if no concessions were offered.

The second method involves using the regression model to estimate average trip rates for each segment, using the coefficients shown for models A and B in Table 32 and the appropriate variables (car ownership etc, Table 31) for each segment. The results of this method are also shown in Table 33, for the three NTS sub-groups. Estimates are made for both qualifiers and non-qualifiers, using appropriate average concessionary and non-concessionary fares. The calculation is repeated for qualifiers, using average non-concessionary fares[11], to estimate trip rates for these people should they not be offered concessions.

The results in Table 33 for the segmental comparison method imply substantially lower generation factors than those deduced by O'Reilly (1990) from the 1985/86 NTS. The most remarkable, and unbelievable, result is that half fare concessions appear to depress trip rates. The explanation of this paradox lies in anomalies in the data for some of the smaller segments. For example, for females who are not employed and have no cars in areas with half-fare concessions, trip rates for non-qualifiers exceed those for qualifiers for all bus service frequencies considered in our calculations. However, the samples of non-qualifiers

Table 33 Observed and estimated trip rates

			Qualifiers		
Sub-group	*Estimation method*	*Non-qualifiers*	*With actual concessions*	*Without concessions*	*Generation factor*
NTS (free)	Segmental comparison	1.57	3.46	2.90	1.19
	Model A	1.82	3.22	2.03	1.59
	Model B	1.79	3.20	1.98	1.62
NTS (flat fare)	Segmental comparison	2.26	3.05	2.50	1.22
	Model A	1.80	2.79	2.07	1.35
	Model B	1.82	2.83	2.09	1.35
NTS (half fare)	Segmental comparison	0.92	1.49	1.61	0.93
	Model A	1.09	2.66	2.01	1.32
	Model B	1.11	2.69	2.02	1.33

are very small, as a result of segmentation of the overall sample, and this unlikely result may be regarded as a statistical aberration. However, these small cells have the same weight as any others in the segmental comparison, and can seriously distort the results.

In the regression analyses, the same data are used, but they are weighted by cell size and the influence of freak data is correspondingly diminished. The regression models therefore provide an estimate of the trip rates that might be observed if samples were large enough to make random variation unimportant. The two models predict broadly similar trip rates and positive generation of trips by half-fare concessions.

The trip rates estimated by the models are, of course, based on averages over fairly large groups of heterogeneous areas. Concessionary fares in free travel areas are uniformly zero, but the full fares used to estimate trip rates without concessions vary from place to place. Effective discounts provided by flat fare and half fare schemes are also very variable. There will also be differences in composition of local populations in terms of car ownership, employment etc. The generation factors shown may thus be taken as averages for each type of area, but in individual areas the models could produce very different results.

This point is perhaps best illustrated by applying the regression model, with the coefficients shown in Table 32, to the elderly population of the four local study areas discussed in section 2. There are two sources of data which can be used for this purpose. The first is the NOMIS database, derived from the 1991 Census. This is not ideal since our study areas do not coincide with ward boundaries, so that the census data relates to slightly different populations, and there is some ambiguity about numbers of pensioners living in two-person households. The second source is the database derived from the surveys in the study areas. These samples were deliberately biased in favour of bus users, and the respondents may exhibit different characteristics from the local pensioner population in general. There is also a gap of four years between the census and our local studies, during which time there could have been appreciable shifts in car ownership and the proportion of people in employment.

The overall bus trip rates (for people in households with and without cars) estimated by models A and B using these data are shown in Table 34, together with trip rates observed in the 1995 surveys.

No estimates are based on 1991 Census data for Woodley, since qualification for concessions there is income dependent, and the Census provides no income information.

The estimates for Woodley and Kingswood involve the assumption that concessionary tokens are used at a uniform rate over the year, reducing average fares by the amounts indicated in Table 24. Various doubts about this assumption were discussed in section 2.6.5, but there seems to be no preferable alternative. The estimates shown for the effects of concessions in Woodley and Kingswood are therefore subject to considerable uncertainty.

Differences between the results obtained using the two data sets are largely explicable in terms of car ownership levels. In Tilehurst, more of the 1995 survey sample (50 per cent) were from car owning households than the census indicated (43 per cent). In Fishponds car ownership levels were almost identical (at 43 percent), while in Kingswood the corresponding statistics were 37 and 40 per cent. Since the models reflect the observation that car owners use buses less than others, the estimated trip rates based on 1995 data are lower than those derived from census data in Tilehurst, higher in Kingswood and much the same in Fishponds.

Model A estimates somewhat higher trip rates than Model B, except in Woodley where service frequencies are lower than in the other study areas. Model B, which

Table 34 Estimated and observed trip rates in local study areas *(bus journeys per person per week)*

		1991 Census			*1995 survey*		
		No concessions	*1995 concessions*	*Generation factor*	*No concessions*	*1995 concessions*	*Generation factor*
Tilehurst	Model A	1.92	3.29	1.71	1.78	3.15	1.77
	Model B	1.63	3.05	1.87	1.49	2.90	1.95
	Observed	..	..		..	5.67	
Woodley (non-qualifiers)	Model A				0.42	1.17	2.29
	Model B				0.73	1.50	2.05
	Observed				1.69	..	
Woodley (qualifiers)	Model A				1.28	2.02	1.58
	Model B				1.60	2.36	1.48
	Observed					3.01	
Fishponds	Model A	2.27	2.63	1.15	2.33	2.69	1.15
	Model B	1.99	2.36	1.18	2.05	2.42	1.18
	Observed	..	..		..	3.19	
Kingswood	Model A	2.12	2.46	1.16	2.34	2.66	1.14
	Model B	1.84	2.19	1.19	2.05	2.39	1.16
	Observed	..	..		..	4.26	

simply differentiates between service frequencies above and below half hourly, is more consistent with the observation that trip rates for Tilehurst residents were much the same regardless of the frequency of their local buses. Model B also has the advantage that it does not (unlike Model A) predict negative trip rates for car owners without concessions in Woodley.

Differences in generation factors derived using models A and B are small, but not trivial, especially for Tilehurst and Woodley.

The trip rates actually observed in the local study areas are much higher than those estimated from either regression model, the ratios ranging from about 1.2 in Fishponds to well over 2 for non-qualifiers in Woodley. The explanation for these discrepancies may be that the local studies samples were filtered (for purposes of economy) to exclude people who rarely or never used buses, whereas the NTS sample included them. Our results would be consistent with proportions of non-bus users in the elderly population ranging between about 15 and 60 per cent. Unfortunately, neither the NTS data available to us nor our surveys provide any independent measure of the relative numbers of bus users and non-users in the elderly population at large, so that it is not possible to test this hypothesis quantitatively. More detailed examination of observed and modelled trip rates produces a pattern which suggests that greater proportions of car-owning elderly people may be non-bus users, but there is no correlation with take-up rates for concessionary schemes, or generosity of concessions.

This apparent lack of agreement proves neither that the models are seriously in error, nor that they are completely reliable. It is therefore necessary to compare this approach with that of the third part of this study, and with results obtained in other research. We shall return to this discussion after presenting the results of our investigations into data supplied by local authorities.

4 Analysis of information from urban areas

This part of the research was based on an extensive set of data on demand for concessionary travel assembled by MVA in the course of a series of recent commissions. The local authorities who had provided these data gave permission for them to be pooled for the purposes of this work. For commercial reasons, most of the information provided is subject to confidentiality conditions, and so cannot be set out in detail here, but we attempt to present the research in a manner which illuminates the findings without disclosing sensitive material.

The information used was in the form of total numbers of concessionary journeys made over a sequence of time periods (for example, quarterly or by four-weekly accounting periods). In some cases this information could be disaggregated by fare band, or by day of the week and time of day. In some areas there had been significant changes in concessionary fare schemes over the periods for which data were available; other cases where there had been no changes served as controls. Other data used where available included local meteorological information, and bus mileage (used as an indicator of service levels).

The urban areas considered in this research, and the changes in concessions which occurred there, are shown in Table 35.

Trends in patronage over periods covered by the study are described in the next section. This is followed by analyses designed to derive appropriate demand models.

4.1 Patronage changes

In order to isolate the effects of a change in a concessionary travel scheme it is necessary to identify any underlying trend in concessionary travel patterns. Table 36 shows trends in areas[12] over periods during which schemes did not change. Examination of these data shows that:

- in areas where free travel has continued, the demand has remained relatively stable; but
- in areas where fares have been charged, demand has fallen steadily in recent years, even though schemes have not been changed.

Table 37 shows similar information for those areas where separate statistics are available by time of day and day of week. This indicates that:

- peak trips have generally increased in areas with free schemes over the last four years;

Table 35 Concessionary fares in study areas

Areas with changes	*Concessions offered in successive stages*			
Tyne and Wear	Free	Flat fare (15p)	Flat fare (20p)	
Lothian	Free	30p flat (20p flat charged by most operators)		
Cleveland (four districts)	Free	10p	Higher fares (some districts)	
Grampian	Half fare	Quarter fare	Fifth fare	10p maximum
Greater Manchester	Flat fare	Series of increases in flat fare		
South Yorkshire	Flat fare (5p)	10p	20p	25p
Areas with no change	*Concessions offered*			
London	Free			
West Midlands	Free (but pm restrictions introduced in 1992)			
Merseyside	Free			
West Yorkshire	Concession varies by time of day			

Table 36 Changes in demand over periods with unchanged concessions *(all days, times of day)*

Original scheme	87/88 - 88/89	88/89 - 89/90	89/90 - 90/91	90/91 - 91/92	91/92 - 92/93	92/93 - 93/94	93/94 - 94/95	Mean annual trend
	Change in demand (%) between years							
A: free	na	na	na	na	2.1	-0.4	1.8	1.2
B: flat	3.8	4.4	1.5	-2.6	*	-5.1	-5.4	-0.6
C: free	na	na	na	2.8	*	*	*	2.8
D: flat	na	na	na	na	na	na	-1.4	-1.4
E: half fare	na	-3.2	-4.5	*	*	*	*	-3.8
F: flat	4.6	*	*	*	*	*	*	4.6
G: flat	7.5	2.8	*	*	-0.5	*	-3.1	-
H: mixed	4.0	4.4	-3.1	*	-1.9	-4.8	-1.8	-0.5
J: free	-1.9	1.9	2.8	3.6	*	-1.4	-0.3	0.8
K: free	na	na	na	na	0.7	-2.5	0.7	-0.4
L: free	na	na	na	7.1	*	*	*	7.1
N: free	na	na	na	5.4	*	*	*	5.4

*na: data unavailable; *: change in concession*

weekday interpeak trips (in all areas) have either remained stable or decreased over the same period; and

changes in numbers of weekday evening and Sunday trips have been large, but with no discernible overall pattern.

Table 38 consolidates the results from observed responses to changes in concessionary schemes. Although the raw data presented here are not adjusted for factors such as the underlying trend and variations in bus mileage, the results exclude any seasonality effects by comparing similar periods in successive years. It is evident that:

the dilution or removal of a free scheme leads to a substantial decrease in the number of concessionary trips;

an increase in flat fare leads to a further but less dramatic fall in trips;

the switch from a low flat fare to half fare has a similar effect to the changes observed when ending a free scheme.

In some cases this analysis can be refined by making adjustments for external factors such as changes in bus mileage, but the results cannot be reported here for reasons of confidentiality. While such adjustments affect the scale of the changes shown in Table 38, they do not significantly alter the overall pattern. At a later stage we discuss how adjustments of this kind may be incorporated in demand models.

In some areas it was possible to examine the impact on changes in concessions on trips of different lengths and full fare values. This indicated that:

when a flat fare is introduced, there is usually a much greater loss of short trips previously carried free than of longer trips;

this results in an increase of around 10 per cent in the average full fare value of concessionary trips made;

in some areas a decline in short distance trips has also occurred at times when there has been no change in the scheme;

changes in existing flat fare have much less effect on average trip length and fare value;

market research evidence suggests that the trip length distribution for free travel and full fares is similar.

4.2 Fitting demand models

All of the effects described in the previous section resulted from changes in schemes which resulted in the continued provision of substantial concessions (generally half fare or less). In order to determine generation factors it is necessary to estimate how demand would change if there were no concessions at all, and elderly people were charged full fares. This requires some form of extrapolation from the observed changes.

Table 37 Changes in demand over periods with unchanged concessions (by day, times of day)

Scheme	Period	Weekday peak	Weekday interpeak	Weekday evening	Saturday	Sunday	Overall
		Change in demand (%) between years					
A: free	1991-1992	5.5	-4.7	-14.7	-2.2	-8.0	-2.4
	1992-1993	-3.4	0.9	6.0	0.7	-5.2	-0.3
	1993-1994	2.0	0.4	-9.7	1.9	-1.8	0.6
F: flat	87/88-88/89	3.2	4.6	na	5.3	10.4	4.6
H: mixed	87/88-88/89	-0.9	4.8	na	na	na	4.0
	88/89-89/90	4.5	5.3	na	na	na	4.4
	89/90-90/91	-0.1	-4.3	NA	NA	NA	-3.1
	91/92-92/93	-1.8	-1.4	-6.2	na	na	-1.9
	92/93-93/94	-4.1	-4.3	-10.3	na	na	-4.7
	93/94-94/95	-5.4	-2.5	10.9	na	na	-1.8
K: free	91/92-92/93	-2.2	1.9	0.8	-5.6	10.7	0.7
	92/93-93/94	5.4	-4.5	7.7	-4.0	2.8	-2.5
	93/94-94/95	3.8	-1.2	4.8	4.7	3.0	0.7

na: data unavailable

Table 38 Responses to concessionary scheme changes (unadjusted)

Area	*Scheme change*	*First period*	*Second period*	*Change in demand*
J	reduced validity	91/92	92/93	-15.5%
C	free to flat	Q3/91-Q1/92	Q3/92-Q1/93	-25.6%
N	free to flat	Q3/91-Q1/92	Q3/92-Q1/93	-20.0%
L	free to flat	Q3/91-Q1/92	Q3/92-Q1/93	-20.8%
M	free to flat	Q2/92-Q1/93	Q2/93-Q1/94	-29.8%
B	free to flat	2/91-12/91	2/92-12/92	-17.4%
H	free to flat	90/91	91/92	-14.1%
L	flat to half fare	Q3/92-Q1/93	Q3/93-Q1/94	-30.8
G	flat +100%	P5/89-P13/90	P5/90-P13/91	1.2
G	flat + 100%	P5/90-P13/91	P5/91-P13/92	-12.1
C	flat + 100%	Q3/92-Q1/93	Q3/93-Q1/94	-9.4
B	flat +33%	P6/94-P7/94	P6/95-P7/95	-7.6%
G	flat +25%	92/93	93/94	-9.8%
C	flat +25%	P6/93-P3/94	P6/94-P3/95	-8.6%
F	flat +21%	P2/90-P7/90	P2/91-P7/91	-7.9%
F	flat +17%	P8/88-P4/89	P8/89-P4/90	-5.7%
L	half fare to fare cap	P4/93-P3/94	P4/94-P3/95	-0.2%

Q=quarter; P = 4-week period; 92/93 etc = financial year

For this purpose, a number of types of demand model were selected, and fitted as well as possible to the observations. In most areas, availability of data allowed only aggregate demand (*ie* total trips of all lengths) to be modelled, but in some we were able to attempt to model disaggregate demand by fare band.

4.2.1 Model types

A demand model is merely a mathematical relationship between demand (in this research, number of trips), price (fare), and any other relevant factors. Various forms of relationship have been suggested or used in the past. There are no compelling theoretical reasons to distinguish between them: any form of model which is consistent with observations, and satisfies certain commonsense conditions, should be acceptable. The required conditions are:

demand should decrease as fare increases;

as fares become very large, demand should fall to zero;

demand should be finite at zero fare.

It is remarkable that the last of these conditions is not satisfied by the most commonly used model; the constant elasticity model. In practice this has not always been important, since zero fares are not always under consideration, and the mathematical relationship is satisfactory over the range of observations. However, when, as in some of the cases under consideration in this research, there are observations of changes in demand as fares are increased from zero, this problem cannot be ignored. In principle the difficulty may be overcome by substituting ‘generalised cost’ for fare in the relationship. Generalised cost includes a monetary equivalent of journey time (which may include access and waiting time in addition to in-vehicle time, all separately weighted) and does not become vanishingly small as fares approach zero. In practice, in the absence of much more detailed data than are commonly available, it is necessary to make somewhat sweeping assumptions about the non-fare components of generalised cost, or else to attempt to infer them as part of a model fitting exercise, as we did earlier in this report (section 2.7).

Two basic forms of model were tested against the aggregate demand data available in this study. They were the familiar constant elasticity model, and the exponential, or proportional elasticity model, so called because elasticity rises in proportion to fare. Here we have sought to incorporate a factor which allows for the observed trends in demand (resulting from demographic change, growth in car ownership etc), which occur over time even when there are no changes in fares, service levels or other readily quantifiable factors.

The constant elasticity model takes the general form:

$$n_2 = n_1\, a\, (f_2 / f_1)^b\, (w_2 / w_1)^c\, (m_2 / m_1)^d \qquad (6)$$

where the subscripts 1 and 2 denote values of variables observed over periods separated by exactly one year (to avoid normal seasonal effects). The number of concessionary trips is represented by *n*, average concessionary fare by *f*, weather conditions (mean daily maximum temperature over the period) by *w*, and total bus mileage in the area by *m*.

The constant *a* indicates the trend in demand, which would occur even if all the other variables were held constant. A value of 1 signifies no trend, while values greater or less than 1 indicate secular growth or decline. The constants *b*, *c* and *d* are elasticities, with respect to fare, weather conditions and bus mileage (representing service levels). If either of the last two variables is found to have no significant effect on demand, or if there are no data to indicate its value, it can be omitted from the model simply by setting *c* or *d* at zero.

The proportional elasticity model takes the general form:

$$n_2 = n_1\, a\, exp[b\, (f_2 - f_1) + c\, (w_2 - w_1) + d\, (m_2 - m_1)] \qquad (7)$$

where the variables and the constant *a* have the same meaning as before, but the constants *b*, *c* and *d* are coefficients instead of elasticities. As before, weather and mileage can be eliminated from the model by setting *c* and *d* at zero.

Either form of model may be adapted to allow for the phenomenon, discussed in section 4.1, of disproportionately large decreases in demand following the imposition of even a small flat fare in place of free travel. A notional 'penalty', representing the inconvenience of cash transactions, or perhaps resentment at having to pay for a service which used to be free, is added to the actual fare when it is non-zero, producing a variable *x* which is used in equations 6 or 7 in place of *f*.

The same basic models were also tested against disaggregate data with changes in demand for different fare bands. Here however, further refinements were possible. Since full adult fares vary with distance, it may be preferable to express the concessionary fare as a percentage of full fare in each band, using the variable *p* (percentage) instead of *f* in the equations. Where 'penalties' are included, *p* is replaced by *q* (the concessionary fare plus penalty as a percentage of the full fare plus penalty).

Other models used in the analysis of disaggregate date were as follows:

The hyperbolic model, used by West Yorkshire PTE (Metro), which takes the form:

(8)

where *k* is a constant. As before, actual fare *f* can be replaced by *p*, percentage of full fare.

Generalised cost models of the form:

$$n_2 = n_1 (g_2 / g_1)^l \qquad (9)$$

where *G* represents generalised cost, and *l* the generalised cost elasticity. The time components of generalised cost were based on estimates of walking, waiting and in-vehicle times appropriate to the journeys under consideration, using conventional weightings and a value of time of 2.5p per minute (rather than the lower value inferred from the local studies) Since the effect of fare variations is sensitive to the non-monetary proportion of generalised cost, these assumptions are quite crucial: they cannot be validated directly, but if they are seriously in error the resulting models will not explain the observed dependence of demand on fare levels.

Generalised cost can also be extended to include a fare penalty; this inclusive generalised cost is denoted by *y*.

4.2.2 Aggregate analysis

This analysis was based on time series data of total concessionary demand in several areas. Pairs of periods, exactly one year apart were identified, and appropriate values for the relevant variables deduced. Fares were adjusted in accordance with the Retail Price Index to compensate for the effects of inflation. Weather and bus mile variables were included where they were available. For each pair, the demand ratio n_2/n_1 was taken as the dependent variable, and the other factors as independent variable in a regression analysis using all the available pairs, whose numbers ranged from 14 to 91, depending on location. Several model forms were tested in each area, and that giving the best statistical relationship in each case is shown in Table 39.

The best fitting models (with significant coefficients with correct signs, and greatest values of R^2) were constant elasticity models in areas B and G. However, the worst fit was also with a constant elasticity model in area A. A number of reasons may be suggested for the poor fit in area A: the patronage data appear to show abnormal seasonal variations; quarterly observations smooth out variations within the time series; the only available weather information was for a location at some distance from the area; and variations in bus mileage were believed to be considerable, but no quantitative data was available; its omission may have distorted the other coefficients produced by the regression analysis.

In other areas the exponential form of model performed best. This is due in part to zero fare data forming part of the time series in areas C, E, and F. Such data can be accommodated with ease in the exponential model, but must be omitted from constant elasticity models, reducing the number of pairs for analysis. The poorest fit with an exponential model is in area D, and may possibly be attributed to changes in eligibility for concessions during the period covered by the analysis, which we have not been able to take into account, and some inexplicable outliers in the data which had to be removed before any model could be made to fit.

Table 39 Aggregate analysis: best models

				Fare elasticity				
Area	*Model type*	*Fare penalty*	*Time trend (annual change)*	*Inferred at conc. fare*	*Predicted at full fare*	*Other variables included*	*N*	R^2
A	CE	No	+0.1%	-0.27	-0.27	w	29	0.30
B	CE	No	-2.5%	-0.27	-0.27	w,m	38	0.74
C	EXP	No	-5.9%	-0.11	-0.51	w	43	0.45
D	EXP	Yes	+0.2%	-0.18	-0.55	w	91	0.40
E	EXP	No	-3.9%	-0.08	-0.78	w	29	0.63
F	EXP	Yes	-2.8%	-0.08	-0.67	w	25	0.48
F	EXP	Yes	+8.0%	-0.04	-1.03	m	14	0.49
G	CE	No	-6.7%	-0.23	-0.23	w	18	0.85
H	EXP	No	-2.3%	-0.20	-0.78	w	31	0.53

CE: constant elasticity; EXP: exponential; w: weather; m: bus mileage

In all areas the model fit was improved by including a weather or mileage variable (where available), and in area B, both. In area F only bus mileage information was available for the first period, which began with free travel, and only weather information for the second, which ended with quite high flat fares.

The best models are not inconsistent with the connection discussed earlier (section 4.1) between fare levels and underlying trends in demand. However, the result for area A is anomalous, for reasons already discussed.

The addition of a notional 10p penalty to all non-zero fares produces small improvements to the fit of the exponential model in some but not all cases. The evidence therefore appears rather weak to make a clear case for or against this concept; much more detailed data would be required to settle this question.

4.2.3 Disaggregate analysis

So far we have been concerned with the total demand for concessionary travel in each area, treating it as a single variable. In most cases there were insufficient data available to do otherwise. However, where there are separate measures of numbers of trips in each of several distance (or fare) bands, it is possible to consider more complex models.

The first reason for attempting disaggregate analysis is that travel by public transport is not a uniform, single-priced product. The trips people wish to make comprise a range of lengths, and corresponding full fares. The significance of any concession may therefore vary. For example, imposition of a 15p flat fare in place of free travel may discourage people from using buses for journeys they can make on foot in 10 minutes, but may have little effect on 10 mile journeys. It is even arguable that people may substitute long journeys for those of medium length, in order to maximise value for money. There is a strong possibility that such effects, which are likely to differ from place to place, may influence the results of aggregate analysis, making them less accurate than desirable. Disaggregate analysis, if successful, could improve estimation of generation factors.

The second reason is the possibility that generation factors may vary with trip lengths. Where there are several operators, with different service patterns involving different trip length distributions, the assumption of a uniform generation factor might favour some at the expense of others. If disaggregate modelling can be applied successfully, it could provide the basis for a fairer system of reimbursement.

Data from two areas were used for disaggregate analysis. The results from one are described in as much detail as is possible subject to the constraints of confidentiality; the other can be discussed only in general terms.

In the first of these areas (labelled C for purposes of discussion here) demand data are available for two periods encompassing changes in concessions, the first from free travel to a flat fare (f_1), the second an increase in the flat fare (to f_2). The proportions of concessionary trips made in each of nine distance bands, under each fare regime, are shown in Table 40; relative changes in demand following each fare change are shown in Figures 7 and 8.

Table 40 Area C: Changes in demand for different trip lengths

Trip length (km)	Percentage of trips at: 0	f_1 (First year after imposition of fare)	f_1 (Last year before fare increase)	f_2
0-1	7.5	4.9	4.5	4.7
1-2	15.7	13.8	12.8	13.5
2-3	16.9	16.7	16.2	16.9
3-4	14.4	14.8	14.1	14.9
4-5	11.4	12.3	12.2	11.3
5-10	25.9	28.6	30.6	30.0
10-15	5.7	6.3	6.4	6.2
15-20	1.9	1.9	2.3	2.0
20+	0.7	0.8	0.9	0.6
All trips	100	100	100	100

According to the results of the aggregate analysis discussed earlier, long-term trends and differences in weather would have resulted in a decline in overall demand of 5.5 per cent between the years spanning the imposition of the first flat fare, and of 5.3 per cent over the period spanning the fare increase. In the event, total demand fell by 17 per cent and 10 per cent respectively. The first change appears to have had the greatest effect on short-distance trips, with an immediate reduction followed by a slower decline, while the second caused greater reductions in long-distance trips, which is puzzling in view of the fact that the flat fare is but a small proportion of the full fare for long trips.

There was some redistribution between distance bands, with the most significant relative gain in the 5 km band (although absolute numbers in this distance band fell with each fare change). The greatest relative fall seems to be at the lowest distances, for which walking may be an alternative to bus travel for many people. However, unresolved discrepancies between data sources cast some doubt on the validity of the statistics for the shortest trips.

A range of models was used in an attempt to reproduce the observed changes. This comprised constant elasticity models based on fares *(f)*, generalised costs (*g*) or generalised costs including fare penalties (*y*), exponential models based on fares (*f*), fares including penalties (*x*) or proportions of full fares (*p*), hyperbolic models based on absolute or proportions of full fares (*f* or *p*), and a model with different constant elasticities for short, medium length and long trips.

In each case the model was applied to the demand observed before the appropriate fare change, adjusted for trends and weather effects. The results are shown in Figures 7 and 8 as estimated demand after each change compared with previous demand, for each of nine fare bands (corresponding to nine distance bands). For each model the relative parameters have been adjusted to produce agreement between the modelled and observed numbers of trips, aggregated over all fare bands.

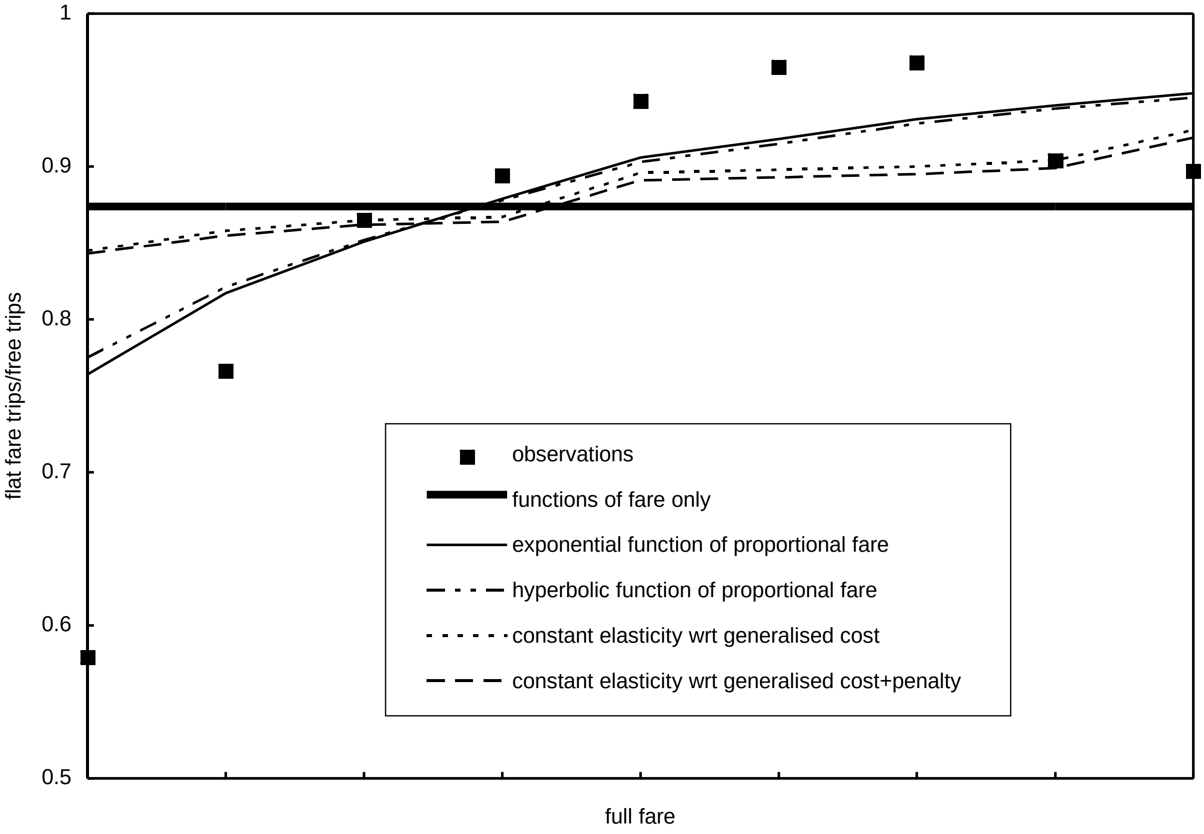


Figure 7 Effect of replacing free travel by flat fare

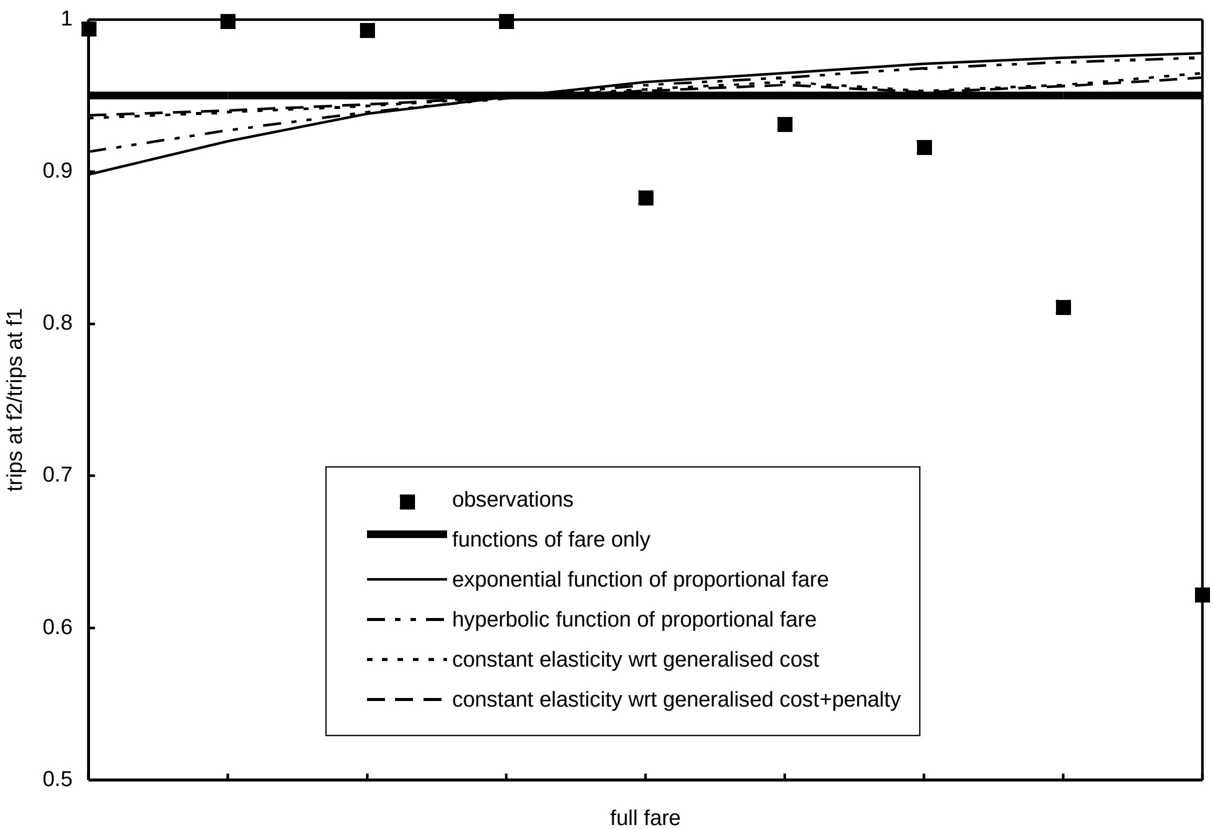


Figure 8 Area C: Effect of increasing flat fare

In each of Figures 7 and 8, horizontal lines represent the results of three models (exponential, with or without penalties, hyperbolic) in which demand is expressed as a function of fare. This is because zero or flat fares are the same across all distances, irrespective of full fares, and the same fare change produces the same relative change in each case. In contrast these models produce different estimates of demand for different distance bands at, for example, half or full fares, since these vary with distance.

Such models explain none of the differential effect, across fare bands, of concessionary fare changes. Those models where demand is expressed as a function of proportional fare (p) or generalised cost suggest that greater proportions of longer distance (higher full fare) trips survive the change from free to flat fare travel, as observed (Figure 7). But this agreement is only qualitative: these models duplicate neither the very large reduction in trips at the shortest distance (even allowing for some uncertainty in the observations), nor the slightly lower survival rate for the longest trips (although these amount to less than three per cent of the total).

However, correspondence between the results of the proportional fare and generalised cost models is much worse in Figure 8, which relates to the subsequent increase in flat fare. As before, the models suggest survival rates increasing with full fare, while the observations show the opposite effect. A marginal improvement to the fit may be gained by assuming higher elasticities for longer trips, but since there is almost no correspondence between such elasticities so derived for the two successive fare changes, there would be little confidence in the application of this technique to further fare changes in area C, or to other areas.

A number of factors may contribute to this disappointing result. Only three months' data were available for demand after the second fare change. This may not have been long enough for demand to reach equilibrium (although the effect of a comparatively minor fare increase should arguably have been much less than the original imposition of a flat fare). There may have been significant changes in service levels, which we cannot model without relevant data. We have assumed a constant rate of secular decline across the periods under consideration, whereas earlier analysis (section 4.1) suggests that the decline may be greater in areas where fares are charged. A much longer run of data would be required for the quantitative establishment of such a factor for area C, and even then the effect could easily be masked by other changes.

Another cause for concern is that our models are incapable of allowing for the possibility that when concessionary schemes change, people may, in addition to reducing the number of trips they make, redistribute the remainder over the various fare bands. However, modelling this effect would seem to present considerable difficulties, even if sufficiently detailed information on travel habits could be obtained.

Similar analysis has been performed on disaggregate data before and after a change in concessionary fares in another area. The results, which cannot be presented here for reasons of confidentiality, seem equally poor, with gross differences between modelled and observed changes in trip rates across different fare bands.

Although the basic observations suggest, as seems intuitively reasonable, that concessionary fare changes should have differential effects on demand for trips of different lengths, we have to admit to being at a loss to provide even qualitative explanations. We saw that the results of aggregate analysis can be severely influenced by allowing for external factors, where it is possible to quantify them. At the disaggregate level, such factors may completely mask the much more complex effects it would be desirable to model. It seems doubtful that the additional effort of trying to resolve these problems, and the costs of sufficient data acquisition (even if this were practicable), could be justified by the resulting improvement in modelling techniques.

5 Generation factors: comparison of results of studies

This research project has used three different methods, relying on independent sources of information, to improve understanding of the amount of travel generated by various types of concessionary fare scheme. Each method has its own weaknesses, which can inhibit confidence in the results it produces, but any consistency between the results of different methods should serve to increase confidence and reduce uncertainty. Accordingly, in this section we bring together the results of all three parts of the study, and discuss their similarities and differences.

The results are presented in the form of generation factors, as defined in section 1.2. In each case n_N is the estimated number of trips in the absence of concessions, that is assuming that everyone was charged the full adult fare for the trip being made. The same methods derived from the different studies may also be used to estimate n_C, the number of trips made under the concessionary scheme. For illustrative purposes, we have estimated n_C for free travel, flat fare and reduced fare concessions, using the appropriate models derived from observations, even though all these types of scheme do not occur in every case. We thus present free travel, flat fare and half fare generation factors.

The results are displayed diagrammatically in Figure 9, which is divided into free travel, flat fare, half fare and two-thirds fare sections. Within each section the generation factors derived from various sources are indicated by their positions on the vertical scale; they are separated horizontally in an arbitrary manner, simply to aid visibility: there is no horizontal scale.

The results labelled TH1 and FP1 are for Tilehurst and Fishponds, derived from the studies of matched areas. Trip rates for people with concessions in these places are compared with trip rates for similar people (in terms of age and car ownership[13]) who enjoy no concessions in Woodley.

The estimates labelled TH2 and FP2 for Tilehurst and Fishponds were obtained by applying the regression formula, from the NTS study, to appropriate local factors. In each case the result is somewhat less than that derived

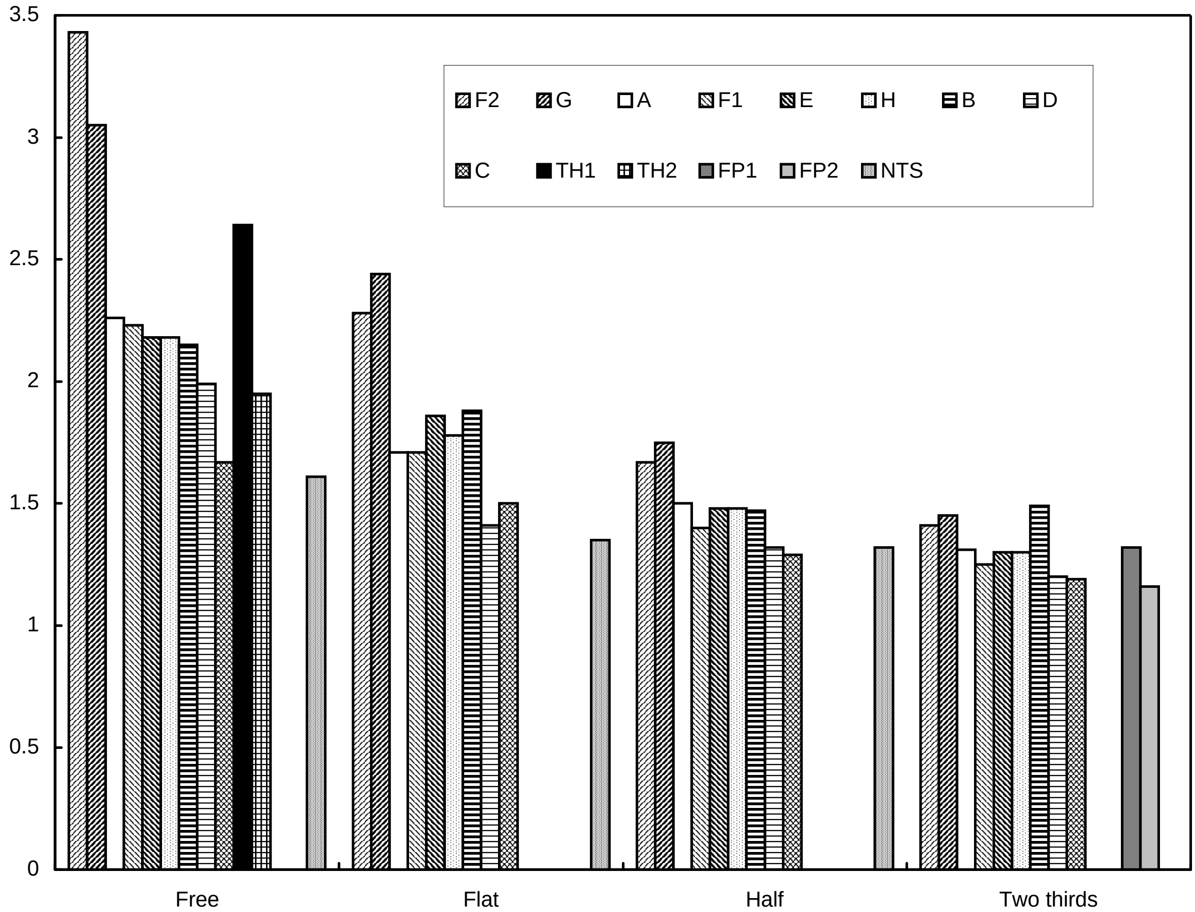


Figure 9 Comparison of generation factors

from the previous method. These discrepancies may be due in part to sampling effects (section 3.3). The local studies were confined to bus users, whereas the NTS samples included non-bus users. Average trip rates for bus users are higher than those for elderly people as a whole, but possibly by different amounts in each area. We have been unable to quantify this effect, so the estimates derived by comparison of local trip rates are subject to some uncertainty.

Estimates are also shown for the free travel, flat fare and half fare segments of the NTS sample. These are somewhat lower than the results of applying the NTS formula to local data. This seems to be due to the heterogeneous nature of the NTS segments, which contain wide ranges of demographic and geographic factors, car ownership, bus fare levels, and, in particular, flat fares. The results shown therefore apply to notional average areas, which may be quite different from the real areas to which the NTS formula has been applied.

The estimates labelled A to H are derived from the aggregate (section 4.2.2) models tested on the data used in the urban area studies. For each type of concession there are several points clustered round a central value, with a few conspicuous outliers. There are a number of possible reasons for the differences. Real or notional zero fares are the same everywhere, but there are considerable variations from place to place in full fares, flat fares and half fares, which all play a part in the models. There may also be substantial variation in demographic factors, particularly in the crucial factor of car ownership, bus service levels, weather and other external factors which cannot always be quantified.

But a more fundamental problem is that all these aggregate models have been fitted to data encompassing changes in concessionary fares over limited ranges, in most cases between zero and rather low flat fares. While the models derived may describe these changes tolerably well, there is no guarantee that they are reliable when extrapolated to full fares, a process which is vital in establishing generation factors. It is remarkable that the two highest estimates, in examples G and F2, involved the lowest concessionary fares and therefore the greatest degree of extrapolation to full fares.

In view of the methodological difficulties discussed here it is not surprising that there are differences between the generation factors derived by different methods. If the more extreme results in Figure 9 are ignored, they form a consistent pattern with the highest generation factors (1.5 to 2.2) for free travel schemes, rather lower values (1.2 to 1.9) for flat fare concessions, and the lowest value (1.2 to 1.5) for half fare schemes. These ranges may serve as a guide for anyone involved in estimating generation factors in particular cases, but they imply wide ranges in resulting values of reimbursement.

It is of particular concern that the results from the urban area studies are so consistently in excess of the averages estimated for the NTS samples. It must be emphasised that equations derived from regression analysis cannot take into account unknown or unquantifiable factors which produce differences from case to case: any prediction from a regression equation is therefore subject to some uncertainty. There will also be variations from place to place resulting from differences in quantifiable factors, as the result derived for Tilehurst from the NTS formula demonstrates. But the pattern would be more convincing if some of the generation factors derived by other methods fell below the NTS sample values. One reason for the bias may be that the NTS sample is drawn from the whole country, and includes rural and smaller urban areas, whereas the urban areas studied in more detail are all in the northern part of the country, where factors like car ownership levels, settlement patterns and attitudes to public transport may be different.

It is also possible that there are methodological flaws in one or more of the approaches. The urban area studies depend on extrapolation from low to full fares, while the NTS regression analysis includes people who have to pay full fares, and may be more reliable in this respect. However, the NTS samples necessarily aggregate wide ranges of dissimilar places, which may have some effect on the results, which we are not able to estimate. In theory, the local studies avoid this difficulty, but the samples were rather small, and we cannot be sure that our pairs of areas were perfectly matched, or that they adequately represented other places.

Unless, as seems unlikely, these remaining doubts and difficulties can be resolved satisfactorily, estimation of generation factors will never be a precise science, and will necessitate a degree of judgement. Nevertheless, this research has produced a new tool which may be used, in the absence of better evidence, to produce at least a first approximation for any area. The regression equation derived from the NTS data may in principle be applied to any locality, provided that appropriate statistics on car ownership, employment, average fares etc could be obtained. The resulting estimate of generation factors may perhaps be regarded as somewhat conservative, in view of the fact that the NTS regression formula consistently predicts the lowest generation factors (Figure 9). Wherever it is possible, analysis of effects on aggregate demand following changes in concessionary schemes, making proper allowance for external effects, may be used to provide some confirmation of the estimates derived from the NTS formula, or to indicate a range of uncertainty.

6 Conclusions

In this research we have used a variety of methods of investigating how various factors influence the use of public transport by elderly people, and, in particular, how much travel is generated by concessionary fare schemes. In view of the wide range of results obtained in previous research studies, it is not surprising that we have been unable to solve all the problems and remove all the uncertainties. We have, however, been able to identify those factors which are most important in determining public transport use by elderly people, and to indicate how they should be taken into account.

The most important influence on bus use is car ownership. Age, income and sex have a major influence on car ownership, but once this is taken into account the first three factors contribute little to explaining levels of public transport use.

The effect of bus service levels has been more difficult to establish. It appears that increasing frequencies to more than two buses per hour may not strongly affect demand by elderly people, but the available evidence is insufficient to provide an unambiguous measure. In practice, this residual uncertainty does not substantially influence the estimation of generated travel.

Fares were also found to influence demand, and this effect is of crucial importance in the estimation of generated travel. All types of concession - free travel, low flat fares, discounted (most commonly half) fares and tokens - were found to generate demand by elderly people, although the evidence on the effects of tokens is difficult to interpret, and provides no clear indication of the magnitude of resulting generated travel.

The results of the three approaches to the research - comparison of bus use in matched pairs of areas, analysis of NTS data, and analysis of data from selected urban areas - are far from completely consistent, but neither are they completely incompatible, and they tend to present a consistent account of the generative effects of different types of concessionary fare scheme.

Changes in concessionary fare schemes can have differential effects on numbers of journeys made over different distances (with different full fares), with some redistribution of journey lengths as concessions change. This has implications for reimbursement where different operators run different types of service, as generation factors may depend on journey length. We have been unable to model these effects convincingly, as the available data were somewhat limited, and important external factors could not be quantified.

Analysis of aggregate demand data from urban areas, over periods when concessions have been changed, produces somewhat higher estimates of generation factors than the formula resulting from regression analysis of the NTS data. A major concern about the former method is its dependence on extrapolation from low fare to full fares. The NTS analysis avoids this problem, but may be subject to other flaws which we have not been able to identify.

Nevertheless, the NTS formula provides a tool which, when used in conjunction with local data on car ownership, employment and average fares, can be used to provide a first estimate of generation factors in any area. Where changes in aggregate demand data can be related to changes in concessions (and any other relevant factors), they may be used to confirm or modify the results obtained using the NTS formula.

7 Acknowledgements

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Notes

1 Concessions may also be provided for people with various kinds of disability, who are not considered in this report.

2 Some authors express the generation factor as the percentage increase in trips caused: by the scheme. Thus if G = 1.5 according to our definition, this would be expressed as 50 per cent.

3 A few respondents held more than £68 worth of tokens, presumably because they had made little use of buses during the previous year.

4 Woodley has to be excluded from this analysis, because of the correlation between income and eligibility for travel concessions

5 For Tilehurst, Woodley (non-eligible) and Fishponds. Woodley (eligible) and Kingswood have been excluded because of the uncertainties in effective fares.

6 It is usual in transport modelling to estimate riding time, walking time etc and apply standard values of time to derive generalised costs. There were insufficient data in this study for this purpose, so we have deduced the non-monetary component of generalised cost by fitting the demand function to the observed trip rates.

7 The generalised cost elasticity exceeds the fare elasticity by a factor of 1+c/f.

8 It is not known whether 'other fee' should be regarded as greater or less than £15.

9 Ordinary adult fares are estimated taking return and off-peak reductions into account, but excluding journeys made by people using season tickets, travelcards etc who did not pay individual fares. By comparison with people of similar employment status in non-qualifying age groups, we estimate that some 5.7 per cent of qualifiers would use season tickets, travelcards etc if no OAP concessions were offered. Assuming an average equivalent discount of 1/3, the notional average fare paid would be some 98.1 percent of the average adult fare. The adult fares shown in Table 30 may therefore be slightly higher than average fares which would be available to pensioners in the absence of concessions, but the discrepancy cannot be determined accurately.

10 This estimate is derived from statistics in the TAS report (Huntley et al 1995).

11 Ignoring the complications of season tickets, travelcards etc which have a relatively unimportant effect on average fares (see section 3.1.7).

12 For reasons of confidentiality, areas are not named. They are labelled with letters (which may not be the same in each table) to facilitate discussion.

13 The Woodley sample of non-qualifiers is heavily biased in favour of car owners. Overall non-concessionary trip rates elsewhere are estimated by weighting the Woodley trip rates according to proportions of people with and without cars in Tilehurst and Fishponds.

Abstract

In most areas of Great Britain elderly people's bus travel is subsidised through concessionary fare schemes. The amount of travel generated by these schemes is important in gauging the effectiveness of concessionary fare policies, and in determining reimbursements to be paid to operators for lost revenue.

A recent 'before and after' study by TRL of the effects of a concessionary fare increase in one area suggested that much more travel may be generated by concessionary fare schemes than previous research had indicated. In order to resolve this apparent discrepancy, a new study was undertaken, combining three different approaches. The first is a comparison of trip rates in two matched pairs of areas,with similar geographical, demographical and public transport characteristics, but different concessionary fare schemes. The second is a cross-sectional study, using information from recent National Travel Surveys. The third is a longitudinal study, examining changes in patronage resulting from concessionary fare changes in several major urban areas.

While each of these studies is limited by the availability of suitable data, there results are not entirely incompatible, and they provide a useful basis for review of concessionary fare arrangements by local authorities and operators.

Related publications

TRL166 *Responses to concessionary fare changes in Tyne and Wear* by R J Balcombe and A J Astrop. 1995 (price £35, code H)

RR291 *An analysis of concessionary bus fare schemes for OAPs using the 1985/86 National Travel Survey* by D M O'Reilly. 1990 (price £20, code B)

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