Concessionary Fares Main Report

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Study Aims and Principles

1. The aim of this report is to present the findings of a research project commissioned by the Department for Transport which will inform the Department's work in developing revised reimbursement guidance. The research team has been led from the Institute for Transport Studies, University of Leeds with significant inputs from Andrew Last of Minnerva Ltd. We have commissioned a paper from Professor Phil Goodwin of UWE, and have benefited from the data and insights of MCL. The Department has convened a Reimbursement Working Group comprising relevant parties from the bus operators and local government. The RWG has been an invaluable sounding board but the research team alone is responsible for the findings and interpretation herein. This report is supported by nine research papers, a digest of which is at Annex A .

2. The national concessionary scheme applies both to people qualified by age and people eligible on grounds of disability. There are quite significant difficulties in studying the travel characteristics of people with disabilities using the available data sources, and the study has focussed on the approximately 90% of concessionary travellers who are qualified on grounds of age.

3. The guiding principle on which concessionary reimbursement is based stems from the 1985 Transport Act and is that arrangements should have the objective of leaving operators 'no better and no worse off' (NBNW) than they would be in the absence of the concessionary scheme. This places the analyst in the position of having to predict what would be the position in a no-scheme parallel universe.

4. In doing this, it is most important to distinguish between two things:-

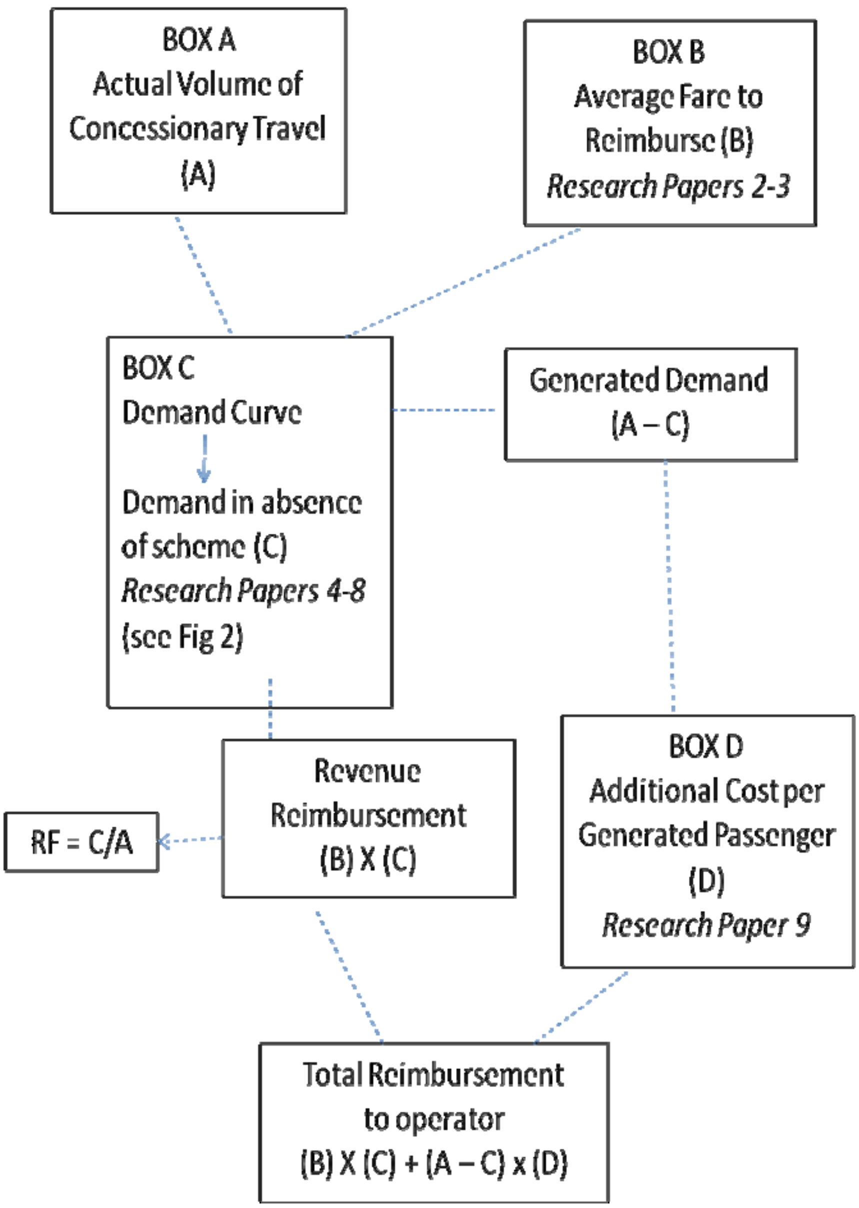
    - The core objective which is to advise the Department how best to give effect and content to the NBNW principle in future reimbursement practice

    - The challenge of interpreting past data from different sources so as to distil the evidence into a set of parameters which can be used to populate the reimbursement model. This is particularly an issue given the number of changes which have taken place in the last decade and the need to allow time for people to adjust their behaviour. Although the past provides the evidence base, the results need to be interpreted with care.

5. In order to give effect to the NBNW principle it is necessary to

- Measure the situation in the 'factual', that is the observed concessionary travel volume (A in Figure 1). This is fundamental but not the subject of this research study.
- Define a basis for estimating the 'counterfactual' -- that is the volume and value of the concessionary trips which would be made at commercial fares in the absence of a scheme. This is the object of this study.

Figure 1 – The Elements of the Problem



6. The estimation of the counterfactual lies at the heart of concessionary reimbursement practice and requires the following questions to be addressed :--

    - What fares would operators offer and ex-concessionary travellers pay in the absence of the concessionary scheme (B)?
    - What is the best estimate of the demand curve--- that is, the relationship linking demand volume with fares (C)?
    - Assuming that demand is not totally inelastic to fare, what are the additional costs to operators of catering for the additional traffic which is generated by the concessionary scheme (D)?

7. A useful indicator is the Reimbursement Factor which is the ratio of the modelled volume without the scheme (C) to the measured volume with the scheme (A).

8. It is vital to remember that while by definition there must be an aggregate demand curve for bus travel in England and a reimbursement formula which is 'right' at the macro level, it is also the case that there are some 300 Travel Concession Authorities and hundreds of bus operators who fall within the rubric of the NBNW principle. So as well as the global or macro issue, there is the question of providing advice which is applicable to local market circumstances.

Estimation of Fares

9. Operators should be reimbursed for revenue forgone on the basis of the passenger journeys that would be carried, and the fares that would be paid, in the absence of the scheme. Fare levels enter into the calculation both as a determinant of generation (because higher full fares imply that free travel would generate more passengers than lower full fares), and as the measure of revenue that would be received from each non-generated passenger. The appropriate fare for reimbursement is reviewed in Research Paper 2.

10. There are practical difficulties for a TCA in measuring fare levels because of the multiplicity of fare denominations and ticket types typically offered. The common practice is to base reimbursement on the cash fare (which can be reported by operators on an auditable basis) or for some large TCAs through survey methods. However, the cash fare is likely to overestimate the average fare that concessionary passengers would pay in the absence of the scheme for two reasons:

    - Without the concession, operators may rebalance the fares structure and/or target the market of eligible people with discounted pricing of some sort, as they already do for some specific markets;
    - The cash fare will be a poor proxy for the actual average revenue earned per non-concessionary passenger because it does not allow for probable take-up of various discounted products such as day tickets or weekly tickets by some eligible passengers in the absence of the concession.

11. It has not been possible to identify specific values to deal with the first issue, although both evidence and logic support the proposition that marketing bus services to the group of people who are eligible for the concession would include fare discounts, in the absence of the scheme.

12. In the past, so-called "basket of fares" methods have been used to estimate effective discount rate by calculating a weighted average fare per trip from assumed usage of different ticket types. However, this relies upon prior estimates of the number of trips associated with each ticket, which will vary significantly depending upon the relative pricing of the different ticket types in the basket, and (to a lesser extent) the distribution of trip frequencies of users. The same problem applies to an average-revenue-per-trip solution, which is attractive because of its simplicity, but is reliant on accurate estimation of trip numbers from ticket sales. However, subject to further validation work, we believe that reimbursement on the basis on average revenue per adult trip may be a suitable approach for rural areas, and/or dealing with small operators and/or small TCAs with low concessionary travel budgets and may be a reasonable fallback/default position to adopt in such cases.

13. An alternative analytic method has been developed which is conceptually preferable. This brings together two data streams, one on the fare structure and the second on the trip frequency distribution in a consistent manner to allocate trips made in the absence of a concession between ticket types. The first characterises the average price of daily and weekly tickets as a multiple of the average cash fare, using data which should be available from operators on an auditable basis. For the second, which is difficult to obtain, Smartcard data—see Research Paper 3-- has been used to identify the observed trip frequency distributions. These trip frequencies are then adjusted from the free fare to the predicted full fare trip frequency distribution using the parameters of the appropriate demand curve. The two streams are then combined to predict what the relative take up would be of different price combinations of tickets. We are encouraged that the trip frequency distributions in the four Lancashire districts for which the sample NoWcard data was analysed and the distribution in the Nottingham card data (Nottingham City Transport use only) are not dissimilar and are also rather similar to the results of a confidential consultant's report on a large conurbation which has been made available to us. The resulting look-up tables could be used by any TCA to identify an appropriate average revenue per trip based on the relative pricing and forecast take-up of each of the operator's tickets. A side benefit of this approach would be that it would greatly reduce if not remove any incentive to the operator to set the commercial fare structure (ie the relativities between singles, returns, day and period ticket prices) with concessionary reimbursement in mind. This is a risk if concessionary reimbursement is on a cash fare basis but a significant proportion of the farepaying market is on discounted day or period tickets.

14. We provide spreadsheets and look up tables which could be adapted and operationalised for use by TCAs, and in the case of TCAs with large concessionary travel budgets, we think the method described in Para 13 and Research Paper 2 is conceptually preferable to either average revenue per adult trip or a negotiated discount approach. Ideally it would be desirable to expand the smartcard database from which these look-up tables have been derived. The initial results suggest that discount factors in the range 8% to 12% relative to the weighted average cash single

and return fare per journey may well turn out to be the outcome when there is significant use of day and weekly tickets. However, it is inappropriate to make a default recommendation.

15. The data required to populate the method would be

- A trip frequency distribution which could be transferred from the Smartcard analysis or for very large TCAs could be the subject of local survey work;
- The fares structure, which is an essential input for TCAs in any case;
- Ticket sales and revenue by ticket type at a level of disaggregation –for example by journey length or fare band—on which guidance should be provided.

The Demand Curve

16. At the heart of the problem is the need to predict the volume of bus travel by eligible concessionary travellers in the absence of a scheme. It is many years since a 'no concession' environment existed in most of England, and therefore it is not possible to observe directly the volume of traffic in the counterfactual. Instead, it is necessary to construct the demand curve from a combination of evidential sources, theoretical reasoning and judgement. This is described in Figure 2.

17. We do not wish to make false claims of spurious accuracy. However, we do see virtue in trying to arrive at a clear, relatively simple method and framework within which the reimbursement system can operate going forward, informed by the evidence base.

18. The approach adopted is as follows. The starting point is the observed evidence, through electronic ticket machine and on-bus surveys of the observed volume at zero fare. Then the most secure direct evidence is the behaviour of concessionary travellers when faced with the change from paying fares in PTEs (around one-third fare in 2005/6 in the four PTEs which charged fares) and in the Shire areas (typically half fare) to the free local scheme. We have good evidence for four PTEs and seven Shire Counties on their volumes prior to the free scheme and for the three years following the introduction of the free scheme (see Research Paper 5).

19. The DfT Guidance distinguishes between 'old' and 'new' passholders. In the rest of this paper, old passholders are defined as those who previously had a pass or took one up as soon as they became eligible. New passholders are those who were induced by the improved terms of the scheme to take up a pass having previously been eligible.[1]

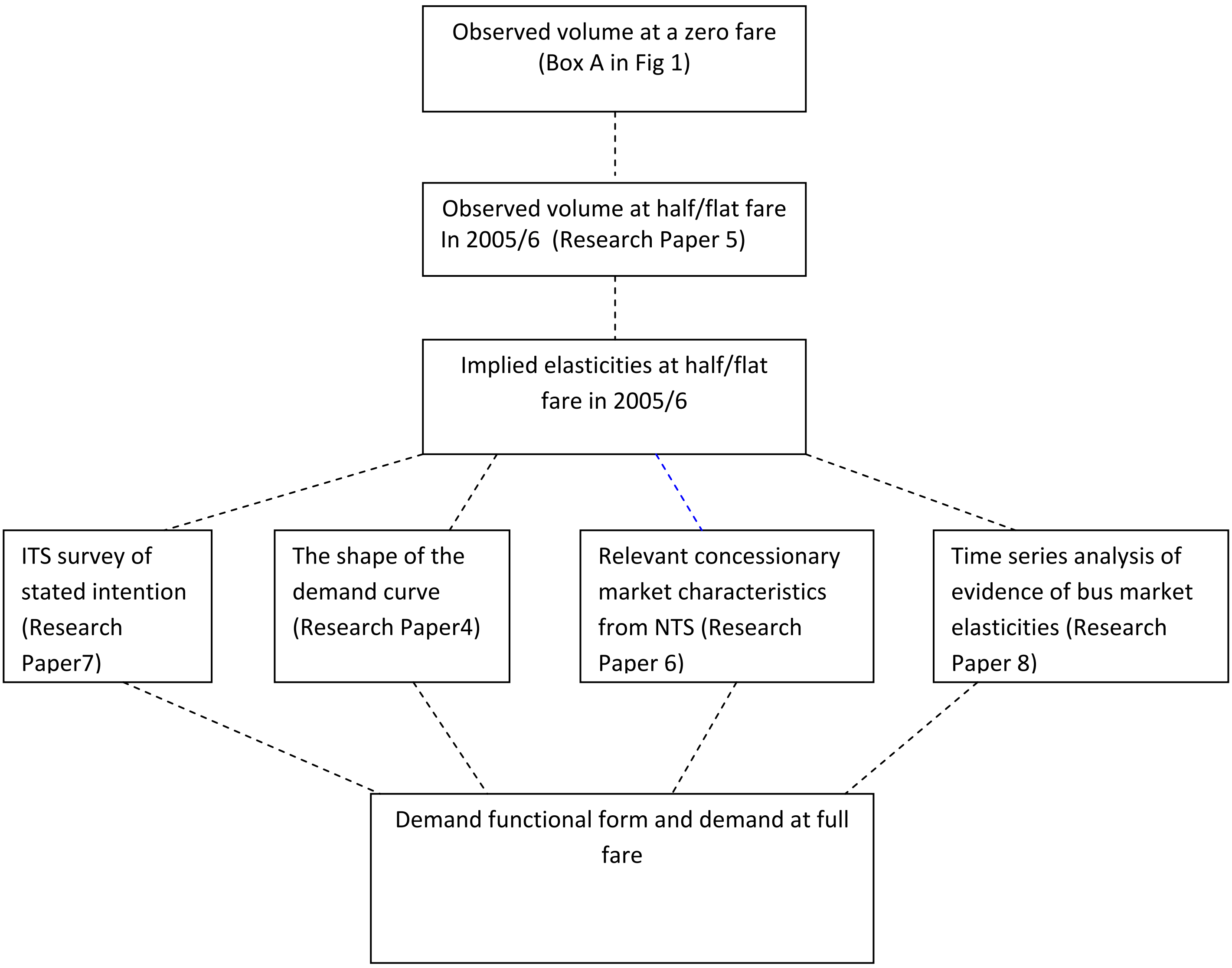
20. In the four PTE areas, concessionary trips by old passholders who had previously paid an average concessionary fare of about 40 pence increased by 24% in 2006/7, 27% in 2007/8 and 33% (range 30-38%) in 2008/9. In the seven counties, with an average concessionary fare in 2005/6

[1] In the shire counties, there is room for debate over whether those previously electing for tokens rather than a fare discount should be regarded as 'new' or 'old' passholders; we have treated them as 'new'passholders with a higher trip rate than completely new passholders as defined above (see Table 10 of RP5).

of about 60 pence, tripmaking by existing passholders increased by 39% in 2006/7, 47% in 2007/8 and 49% in 2008/9. In the shire county 2008/9 results there were two outliers (one low, one high) with the other five counties in the range 40-49%.

21. If a directly proportional elasticity curve (see para 23 below) is fitted to this data, a series of point elasticities at prevailing concessionary fare *for 'old' passholders* can be derived. In the PTE areas, at a fare of 40 pence, the average point elasticity from 05/6 to 06/7 is -0.22, from 05/6 to 07/8 is -0.24 and from 05/6 to 08/9 is -0.29. For the seven counties and at an average concessionary fare of 60 pence, the equivalent elasticity estimates are -0.32, -0.38 and -0.37. However, the 08/09 results for the shires are a little more uncertain because of the measurement changes associated with the introduction of the National scheme. We recommend that close attention is given to the 09/10 results when these become available.

Figure 2 Constructing the Demand Curve

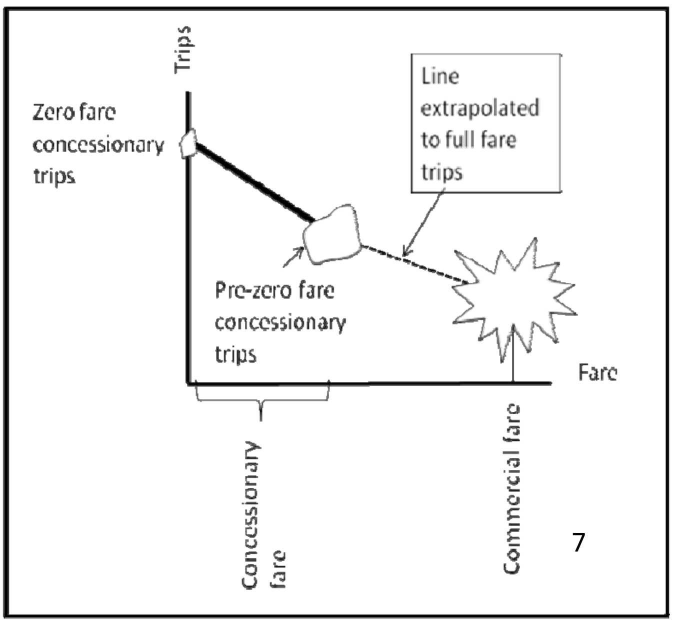


22. The observed data reported in para 20 is the best evidence on the demand behaviour of old passholders in the context of recently experienced concessionary fares. We return to the issue of new passholders below. However, NBNW reimbursement requires extrapolation from this evidence so as to estimate the volume of trips that would be made at commercial fare (see Figure 3). This requires us to propose a demand curve of a particular chosen form and to calibrate it against evidence from other sources.

23. There is little direct evidence on which to choose between alternative demand forms. However, there are arguments that suggest the chosen form should have particular properties – for example, demand at a zero fare should be a finite quantity. In earlier years, implicitly a constant fare elasticity curve was frequently used which may have been adequate for reimbursing operators for the difference between half fare and full fare but is not appropriate for dealing with free fares. A model form used by some TCAs and adopted by DfT in recent Guidance assumes that the point elasticity of demand is directly proportional to the fare level (the 'exponential' model). However, practitioners have been concerned that this gives rise to implausibly high elasticities at high fare levels. There are also theoretical arguments—see Research Paper 4-- that suggest that when the relevant market consists of submarkets with different elasticities – for example car available and non car-available bus users – then the increase in elasticity with fare will be less than directly proportional. Consequently, the concept of a 'damped' exponential model has been explored under which the point elasticity increases less than directly proportionately to real fare with the relationship given by the value of the damping factor. For example a value for the damping factor of 0.8 implies that a 1% increase in real fare is associated with a 0.8% increase in fare elasticity.

24. Ideally the damping factor and the point elasticity at full fare would be estimated simultaneously. In practice, this is not possible and we bring to bear evidence from a range of sources to help select the combination of damping factor and full fare elasticity which we consider best fits the evidence. We therefore next proceed to summarise the evidence on full fare elasticities.

Figure 3



Evidence on elasticities

25. There is considerable past literature on fare elasticities, although it is often weakened by not being sufficiently precisely specified to apply in a concessionary reimbursement context. It also tends to be concerned with the market for bus travel as a whole (and not the individuals eligible for concessionary travel), is relatively old, and generally appears to quote elasticities at the full (non-concessionary) fare. In contrast, data from the April 2006 change to free travel is recent and focussed on the concessionary travel market. However, it provides information only on concessionary demand at the concessionary fare (low) end of the demand curve.

26. From the 1980s onwards, a number of studies of concessionary fares in specific markets were conducted by TRL. These were either 'before and after' comparisons within district or paired comparisons across districts. The small sample sizes make generalisation difficult in particular with regard to the transferability of absolute elasticities. There are also issues about the comparability of the elasticity calculation methods, for example a point elasticity at prevailing concessionary fare is a different entity from a linear arc elasticity estimated from a change in concessionary scheme.

27. That said, we can find some indications as to the nature of the market from past studies:

- Price elasticity for different groups of the elderly ranged from 0 to -0.7.
- Car ownership is an important determinant of bus use and demand for bus travel by car-owning pensioners is much more sensitive to concessionary fare levels than for those without cars.
- Partly as a consequence of higher car ownership, medium and low density areas show some evidence of higher elasticities.

28. We can also examine elasticities in the bus travel market as a whole. Much of this work was reported in TRL Report 593 ("White Book" or "Black Book 2"), which can be regarded as a useful review of the state of the art as at 2004.

- Short run full fare elasticities had been increasing over time due to increasing car ownership and less reliance on the bus over time.
- Long run elasticities are considerably bigger than short run, up to three times (Dargay and Hanly).
- Elasticities are smaller in denser, urban areas, but may be highest in suburban areas where there is good public transport, low road congestion and so both private and public transport are realistic possibilities for travellers.
- Off-peak elasticities are about twice as high as peak elasticities (this is also broadly true outside UK).
- Wardman's meta analysis gives an elasticity at full fare for elderly of -0.5, which is 25% greater than the market as a whole; and of -0.2 (50% lower than the whole

market elasticity) at prevailing concessionary fare. His results are statistically significant but rely on a small subset of observations.

29. In the course of this project, a number of sources of information have been explored – see Figure 4 – from which elasticities may be obtained including:

- The National Travel Survey (NTS)
- The Department's STATS100A database of bus traffic and revenue
- Scheme-specific data on concessionary trips following the introduction of free travel in four PTE areas and seven Shire Counties
- A telephone survey specifically commissioned for this study of those eligible for concession on grounds of age

30. All of these sources have strengths and weaknesses as outlined briefly in the Figure 4.

31. Elasticity evidence associated with the immediate aftermath of the introduction of free travel is likely to reflect short –term reactions to change. The long-run elasticities will be bigger because of the time delay in some of the reactions to fare changes, for example change of car ownership status or even home location. Past practice when fares were being charged has tended to use short run elasticities, but logically it is considered that NBNW principles would be better served by using long run, post-equilibrium elasticities. There is some, but limited, evidence to quantify increments in elasticity values from short run to long run for the market as a whole.

Figure 4 Sources of evidence on elasticities

SOURCE	DESCRIPTION	STRENGTHS	WEAKNESSES
Before/after in 4 PTE and 7 Shire Areas (Research Report 5)	Estimated elasticities at half/flat fare	Derived directly from concessionary market	Requires adjustments; elasticity values depend on assumed functional form
STATS 100A (Research Report 8)	Econometric estimation of whole market elasticities and split between concessionary/commercial for PTE areas	Estimate of full fare short-run elasticity independent of functional form assumptions; comparability with Dargay/Hanly	Aggregate data; Assumptions re commercial/ concessionary split; uncertain read across from commercial to concessionary elasticities
National Travel Survey (Research Paper 6)	Panel data giving trip rates over long time period	Evidence on changes in socio-economic characteristics of concessionary travellers; elasticity model incorporating car ownership etc effect	Imposed functional form to obtain full fare elasticities
ITS telephone survey (Research Paper 7)	Stated Intentions Approach	Estimated els at half and full fare; breakdown by journey purpose, socio-economic status, area time	Possible biases in results

32. We now provide a very brief bullet point summary of the main evidence sources starting with the Department's Stat100a data

- The Stat100a analysis gives us estimates of the 'whole-market' (ie aggregate commercial plus concessionary traffic) elasticity of total volume with respect to average revenue over the period 1989/90—2006/7. As a first order approximation under free fares for one segment of the market, the full-fare elasticity for the non-free segment of the market is the whole market elasticity divided by the proportion of trips which is non-concessionary.

- Ideally we would have estimated separate models for the different market segments; unfortunately, the demand data to do that do not exist. Where partial data exist – the PTEs have been a good source for 1997-2003 – it is possible to decompose the whole-market elasticity into separate elasticities for the concessionary and commercial market segments

- Our simplest models gave constant short run elasticities for the whole market typically in the range -0.16 to -0.22. When a more complex form was run which allows the elasticity to vary over time, but remaining constant with respect to average revenue, there is a clear pattern of elasticities diminishing slightly over time, possibly reflecting the increase in proportion of the market that is concessionary . At the end of the series (2006/7), we found short run elasticities of the order -0.2 to -0.3.

- The relationship between short run and long run elasticities varies according to model specification. In general, a whole-market long run point elasticity at prevailing average revenue per trip including one day and period tickets in the range -0.3 to -0.4 is supported.

- We do not find, using this data set, systematic variation of elasticity with average revenue per trip. Our explanation for this is primarily that the model is being run on county averages and there is too much aggregation to be able to detect variation with average revenue per trip. Disaggregate data, for example between route groups with different socio-economic characteristics, would be a better test for elasticity variation.

- We found neither systematic regional variation nor variation in elasticity according to county-type (based on things such as local government structure, population density, etc.)

- Segmenting the whole-market elasticity, we were able to deduce short run point elasticities for the commercial market in the PTEs of between -0.28 and -0.44 over the years 1998-2003. This was pre-free scheme, so there are also point elasticities for the concessionary market at prevailing concessionary fare of between -0.1 and -0.15. These results assume a particular functional form relationship between concessionary and commercial elasticity. The models underpinning them had a variety of functional forms, but the outputs are essentially independent of the functional form of the underlying model. We should note that the PTE data are aggregated over all six PTEs, and so the prevailing concessionary fare elasticity includes two PTEs at zero fare. Thus the elasticity at prevailing non-zero concessionary fare can be expected to be bigger than the range indicated by about 50%, so, perhaps -0.15 to -0.22 or so.

- Given some general knowledge of the size of the concessionary market relative to the commercial market – and this can range from concessionary being about 30% of commercial to concessionary being the same size as commercial - then from a starting value of -0.25 for the short run whole market elasticity, we deduce commercial elasticities ranging from -0.3 to -0.4 in the short run and -0.4 to -0.52 in the long run.

- These are elasticities for the sum of peak and off-peak and across all journey purposes and this needs to be borne in mind when using commercial elasticities as a reference point for the plausible elasticity of the current concessionary market segment if it was paying full commercial fares.

33. NTS analysis

- The NTS analysis gives a picture of the changes in the concessionary travel marketplace over the period when the scheme moved from discretionary to mandatory, and then to free local and free national. Among interesting findings are : the trip frequency distribution of passholders ; the predicted background trends in concessionary travel in the absence of the scheme (-3.0% pa in the Mets and -1.7% pa in the Shires) ; the changes in the proportion of farepaying trips made by those eligible for concessions. These background findings provide colour and context for our work which cannot be obtained from other sources.

- Of particular interest is an analysis of trends in car ownership and licence holding of bus users. In 2001, bus users who were eligible for a concessionary pass had much lower licence holding and car ownership than other (non-eligible) bus users. The situation was vastly different by 2008 ; eligible and non-eligible bus users were by then far more alike in terms of car ownership and licence holding. This catching-up was particularly strong in the Mets and probably is the dominant factor in the differential background trend reported above.

- The analysis of NTS enabled trip rate models to be built on eligible individuals. The NTS has complex weighting procedures to ensure sample representativeness and there is no reason to suppose that bus trip rates are either over or under represented in the NTS. By stripping out background changes, a counterfactual was established to assess the impact of free travel. The model estimates that the introduction of free travel increased trip rates by 26.5% in the Mets and 45.4% in the Shires. At prevailing concessionary fares, this produced elasticities of -0.23 in the Metropolitan areas and -0.375 in the Shires. If a directly proportional elasticity model is used , the implied elasticities at full fare are -0.65 in the Mets and -0.75 in the Shires. These are estimated for 2008, that is two years after local free fares, so there is a question about how much of the long run adjustment has been made.

34. PTE/County analysis

- The PTE/County data is the strongest evidence on the actual concessionary market behaviour in response to the creation of the free local scheme in 2006 and these results have been discussed above in paras 18 to 21.

- It is weak on Midland and Northern shire counties and unitary authorities and other interpretation issues arise. In particular, a key feature of the County data is the considerable increase in concessionary pass take-up since the introduction of free travel. While induced or 'new' passholders account for around 10% of total passholding in the four PTEs studied, they account for around 40% of total passholding in the seven counties.

- Considering the old passholder market segment, and assuming a directly proportional elasticity model, the point elasticities at a real fare of £1 in 2005/6 prices for the four PTEs are -0.54 in 2006/7 and -0.60 in 2007/8 while for the seven counties the equivalent results are -0.55 and -0.64. [2]

35. Telephone survey

ITS commissioned Accent Marketing and Research to undertake a survey of eligible concessionary travellers. A conscious decision was made to focus on respondents who make bus trips. The sampling technique ensures that the trip frequency distribution of those making trips is known and can be compared with NTS. The elasticities reported below are person-weighted elasticities; if weighted by trips to allow for differential elasticity by frequency, the values are of the order of 10% lower in absolute terms.

- The headline person-weighted full-fare elasticity from this survey, again using a direct proportional elasticity model is -0.58 (trip weighted elasticity -0.51). Breaking this down by area type, we have -0.47 for the Mets, -0.53 for the Unitaries and -0.60 for the Shire Districts.

- The method also admits estimates of point elasticity at concessionary fare. Taking the 2005/6 situation to be 4 PTEs 36% of full fare and Shires 50% of full fare, we find elasticities of -0.17 for the Mets, -0.27 for the Unitaries and -0.3 for the Shire Districts at prevailing concessionary fare.

- More granular classifications based on District type could be undertaken at a later stage if desired.

Overview

36. Our headline results for the likely range of long-run point elasticities for concessionary traffic if it had to pay commercial fare is as follows:

	central estimate	reasonable range
Metropolitan	-0.5	-0.45 to -0.55
Other Urban	-0.5	-0.45 to -0.55
Rural	-0.65	-0.6 to -0.7

[2] Note—average fares in 05/6 at 05/6 prices were—four PTEs 112.9 pence ; seven counties 119.7 pence.

37. The work for this project, summarised above, shows that:

- Commercial full fare elasticities are a little smaller than previously estimated, but not out of line with the prevailing wisdom of the 1980s, being of the order of -0.3 in the Metropolitan areas (short run) and a little larger in areas outside the Mets where concessionary travel forms a bigger part of the market. To the extent that non-Metropolitan areas have traffic mixes and fare levels similar to Metropolitan areas, then we would expect the elasticities to be similar also.
- There is a lag in adjustment, but the gap between short run and long run is perhaps of the order of plus 50% rather than plus 100% from the range of models we have estimated from the Stats100a data.
- There is some evidence that elasticities are a little higher in less densely populated areas, driven by the larger size of the concessionary market relative to the commercial market in such areas..
- At prevailing concessionary fares (pre free local), the different evidence bases (Stats100a decomposed; NTS; Telephone survey; PTE/County analysis), suggest a range -0.15 to -0.3 short run.[3]
- At full fare, elasticity for the concessionary market is somewhat higher than the corresponding commercial elasticity, primarily because of the different journey purpose mix and off-peak nature of the concessionary market. TRL report 593, the 'Black Book' table 6.26 reports off-peak elasticities significantly higher than peak. We therefore use our central estimates for the commercial elasticity as lower bounds for our range of concessionary elasticities.
- In coming to this view we are of the opinion that new passholder bus tripmaking would be a small proportion of the ex-concessionary market at full fare so that it is reasonable to interpret our elasticities as the market segment elasticities for concessionary trips if they were paying full fare.

38. Overall, we conclude with fair confidence that the balance of evidence supports a concessionary market long-run point elasticity at 2005/6 full fares in the PTE areas of -0.45 to -0.55. We would use the same values *at a given fare and with the same mix of traffic* for the cities in the Shire Counties such as Hull, Bristol, and Southampton etc. In town and rural England, we think the balance of evidence supports slightly higher elasticities, and would advise a long run point elasticity in the range of -0.6 to -0.7.

The Relevant Demand Curve

39. The switch from a concessionary fare to a free local and then free national scheme between 2005/6 and 2008/9 has had a number of effects on the concessionary market. It has caused existing or 'old' passholders to travel more and has induced new passholders to take up a pass and make bus trips. Pass take up was previously high in the PTE areas but in some shire counties passholding has more than doubled and concessionary tripmaking has increased by of the order

[3] The county analysis would indicate a higher figure than this if new passholders were included.

of 50%. For the purpose of calculating elasticities, these changes have created difficulties, particularly during the transition.

40. We do not think it is right going forward to base reimbursement on a curve drawn from an estimated proportion of the market (ie old passholder trips/total concessionary trips). This was a device during the transition whose usefulness is now outlived. Going forward, reimbursement needs to be based on a 'whole concessionary market' approach working directly from the measured volume of trips at zero fare to the modelled volume at full fare (the ratio being the Reimbursement Factor). In order to do this, we need to construct the 'whole market' demand curve by combining the old and new passholder curves.

41. It could be the case that the old passholder and new passholder groups are drawn from the same market with similar shaped curves but different trip rates. But we think this is implausible. Our interpretation of the evidence taken as a whole is that the changes in 2006/8 have significantly changed the demand for concessionary bus travel, widening the market to include a much higher proportion of car owners and permitting a greater degree of discretionary travel by bus. This means that the aggregated ('old 'plus 'new' passholder) demand curve is shallower in the region from concessionary fare to free fare than had previously been supposed; a new sub-market has been added to the previous market. If the policy were to be reversed, then with a suitable time lag, this new sub- market would drop out again.

42. Therefore, above the concessionary fare levels of 2005/6, we consider the market would revert to the 'old passholders' and it is their demand characteristics which we need to represent when modelling the upper segment of the demand curve between concessionary fare and full fare and beyond.

43. Between concessionary fare and full fare, we have evidence from Research Paper 4 that a damped negative exponential (ie with elasticity increasing less than directly proportionately with fare) is a reasonable functional form to represent behaviour in this market. The ITS team considers that the damping factor for old passholders is more likely to lie in the range 0.8 to 0.9 than in the lower part of the range proposed in RP4. This is the range which best links the full fare and pre 2006 concessionary fare elasticities and some weight is attached to the logical relationship to a generalised cost elasticity. Specifically, we think the PTE/MCL and NTS based model projections of elasticities at full fare provide rather high values with a directly proportional elasticity model so we favour a somewhat damped model *in the territory from concessionary fare to full fare.*

44. When the upper section of the demand curve and the relatively more fare responsive lower section are combined together, the best fit single demand curve has a damping factor of just over 0.7. This reflects the effect of adding in the relatively more elastic new passholder sub-market and is in the middle of the range discussed in Research Paper 4 (though at the upper end of Goodwin's range).

Abstraction from commercial farepaying traffic

45. A further adjustment is required in specifying the demand curve of interest. *For the purposes of elasticity and reimbursement estimation,* the correct demand curve is the demand for bus travel by concession-eligible people at every fare level. But the volume of commercial fare-paying traffic by those eligible for concessions is impossible to observe in ETM or other count data. It is therefore difficult to make well-founded estimates of the abstraction ratio, that is, the proportion of the growth in traffic as a result of the free scheme which is abstracted from commercial rather than generated.

46. This issue of abstraction applies particularly to “new” passholders – how many of the free trips they now make were previously being made at full fare? – and potentially also to “old” passholders after April 2008 in respect of non-generated cross-boundary or out-of-area trips which are now free and were previously paid for. (Generated trips are irrelevant.). However, one of the key findings of the survey is that only a small proportion of the growth in 2008/9 was due to cross-boundary and out-of-area trips.

47. The state of the evidence on the abstraction ratio is not fully satisfactory because it is so difficult to develop a consistent series of commercial and concessionary traffic from the STATS 100A data. However we believe that the years 2006/7 to 2008/9 which might have been expected to show a large excess to trend loss of commercial traffic if there were a high abstraction ratio did not in fact do so.

48. Our reading of the trip rates and relativities between concessionary and fare-paying trips by eligible people in the NTS data leads us to propose for illustrative purposes an abstraction ratio of 30%[4] to be applied to the proportion of new passholders. Thus in PTE areas which used to charge fares, trips by new passholders as defined above account for 5.8% of concessionary trips so we have allowed at concession fare and above for an abstraction from commercial fares of 1.75% of the total concessionary market. This both modifies the demand volume at concessionary fare and above and slightly modifies the elasticity at full fare. In the County areas for which we have good information, trips by new passholders account for 23.2% of concessionary trips, so we have allowed an abstraction of 7.0%. [5]

Calculating the Reimbursement Factor

49. From Fig 2 above, the Reimbursement Factor (RF) is the ratio of modelled demand volume in the absence of the scheme to measured volume in the presence of the scheme. Reimbursement for revenue forgone is the product of average fare for reimbursement, observed volume and the RF. The building blocks from which to assemble the whole concessionary market demand curve from which the RF is obtained are :

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[4] From Research Paper 6, table 4, an abstraction factor of 30% is used. This is consistent with New Passholders before they choose to get a pass having a trip rate of twice the average trip rate of eligible non-passholders and after obtaining their pass, a trip rate of around half the Old Passholder trip rate.

[5] Counting those diverted from tokens as new passholders with trip rates as in RP 5 tables 5 and 10.

- The evidence from the four PTEs and seven shire counties on the impact of moving from concessionary fare to free measured over the period 2005/6 to 2008/9. (paras 18-21)

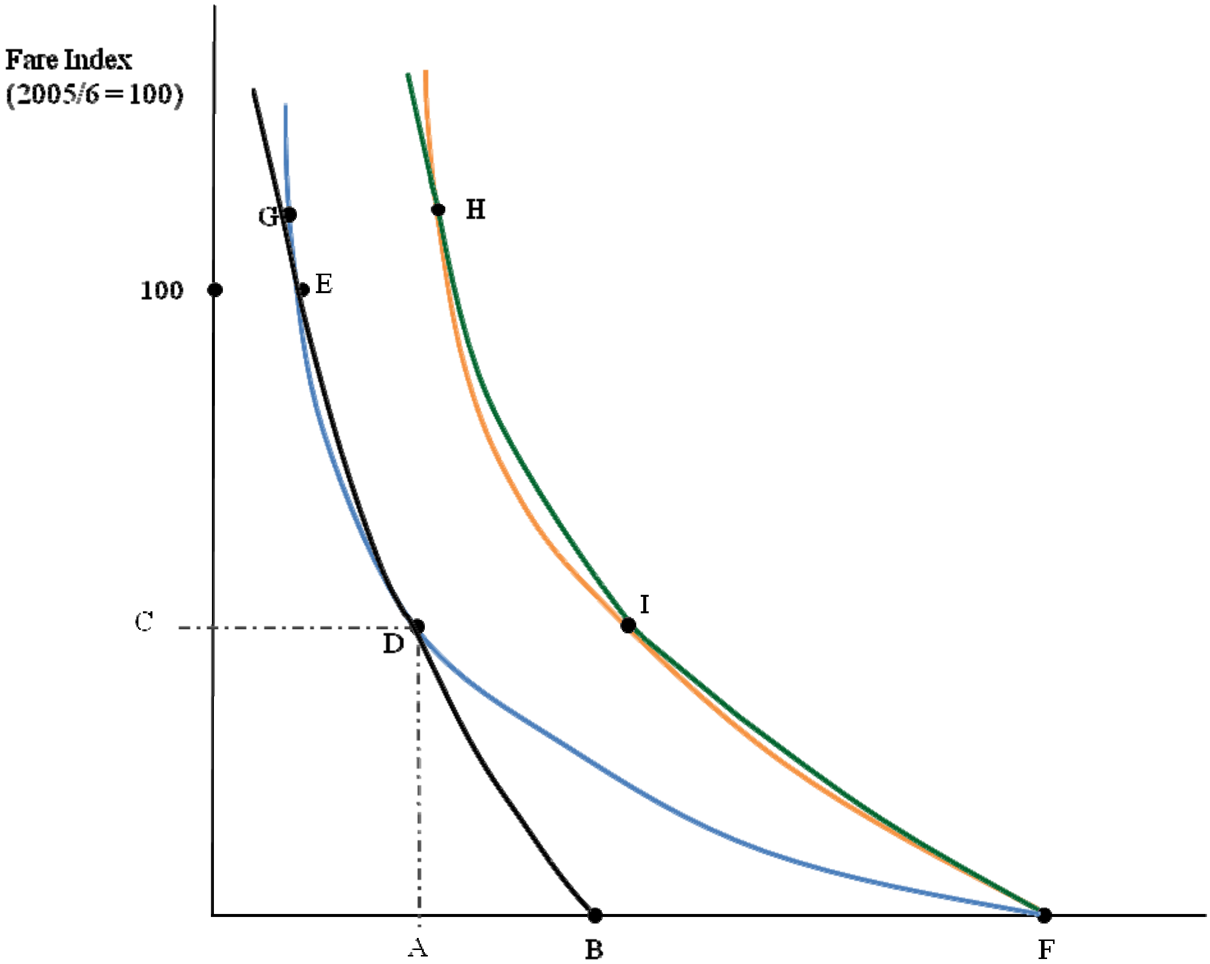
- The evidence and argument to support the negative exponential form of the demand function and the level of damping to be applied (paras 22-24 and 43-44)

- The evidence on the likely value range of full fare elasticities for 'old' passholders (paras 25-38)

- The method of aggregating together old passholder and new passholder market segments to obtain a 'whole concessionary market' curve (paras 39-42).

- The allowance for a proportion of observed concessionary travel to be diverted from commercial fares rather than generated (the abstraction ratio described in paras 45-48).

50. The assembly process is depicted in Figure 5. It starts with an 'old passholder' demand curve consistent with the old passholder generation rates described in para 20. It then adds a tail to the curve to represent the new passholder submarket. This piecewise curve is then shifted to allow for the element of abstraction from commercial farepaying trips. Finally a single whole market curve is fitted as an approximation to the piecewise curve. This has the attractions of tractability and relative simplicity for use in practice. The recommended whole market demand curve is based upon a damped form of exponential model of the form $T = k * Exp(\beta F \lambda)$ where T = trips at fare F, β is a proportionality constant and λ is a damping factor. This allows the Reimbursement Factor RF, the ratio of trips at average fare F to trips at a zero concessionary fare to be calculated. The model details are described in Annex B and an application spreadsheet has been provided to the Department for Transport.



A: old passholder counterfactual volume 2008/9 at 2005/6 concessionary fare
B: old passholder volume 2008/9 at free fare (including 'type 1' new pass holders)
C: prevailing concessionary fare 2005/6
D: old passholder volume and fare at 2005/06 concessionary fare
E: old passholder volume/fare at 2005/6 full fares
F: whole concessionary market observed volume 2008/9 at free fares
G: volume and fare of old passholders at 2008/9 full fares
H: whole concessionary market volume with shift for abstraction at 2008/9 full fares
I: whole concessionary market volume with shift for abstraction at 2005/6 concessionary fares

Figure 5: Construction of illustrative single demand curve

51. The model is calibrated to the observed trip generative effects in the four PTEs and seven County schemes reviewed in RP5. The 2008/9 volume at zero fare and the volume at 2005/6 concessionary fare are treated as observations and the demand curve is then extrapolated to full fare and above. The key inputs which drive the results, and which can be varied in the spreadsheet application are

- The old passholder generation factor from concessionary to free
- The old passholder damping factor
- The proportion of new passholder trips at zero fare
- The abstraction ratio from commercial fares

52. The model produces two intermediate outputs ; these are the old passholder demand elasticity at 2005/6 concessionary fare and the projected 2005/6 old passholder demand elasticity at full fare. These are not used in computing the RF but are useful indicators for comparing with the external evidence as checks on the credibility of the model values. In Table 1 below, the input values are shown in the top section of the table and the intermediate outputs in the middle section with the final outputs in the lower section.

Table 1 Concessionary Reimbursement Model		
	PTEs	Shires
Input Values		
Old passholder trip ratio (2005/6 : 2008/9)	0.753	0.671
Fare Index (Conc Fare/Comm Fare 2005/6)	0.36	0.50
Damping Factor λ	0.8	0.9
New pass holder trip proportion	0.058	0.232
Abstraction Factor	0.3	0.3
Intermediate Outputs		
Point el at 05/06 conc fare for old passholders	-0.23	-0.36
Point el at 05/06 full fare for old pass holders	-0.51	-0.67
Final Output Values		
Elasticity constant (β)	-0.67	-0.84
Whole market damping factor (λ)	0.72	0.64
Whole market el at projected 08/09 full Fare	-0.51	-0.56
Reimbursement Factor at projected 08/09 Full Fare	0.50	0.42

53. The principal model results are: for the PTEs a point elasticity at projected 08/09 average fare of -0.51 and a RF of 0.50 and for the Shires a point elasticity of -0.56 and a RF of 0.42. While there is a range of plausible input values for all parameters, and there is scope for systematic sensitivity testing, we consider that the results reported in table 1 are within the zone of reasonableness and have certain desirable properties. Specifically, the model output values

- reproduce demand elasticities at prevailing 2005/6 concessionary fares within the ranges outlined in para 21
- reproduce old passholder elasticities at full fares within the expected ranges

- produce an output value for the damping factor which is well within the range mooted in RP4
- generate whole market elasticities at full fare which we believe to be very credible.

54. There are numerous reasons why the results shown above need to be treated as credible model predictions rather than a definitive unique answer. One set of reasons surrounds the inherent difficulty of predicting the response to a fares scenario which is far from observed reality. A second set surrounds the question of whether the market can be considered to have 'settled down' only three years into the free local era and one year into the free national scheme. While on our model that will not in itself affect the point elasticity of demand at full fare, it will affect the shape of the lower half of the demand curve. For that reason the market trends in 2009/10 and 2010/11 will require careful scrutiny. Thirdly, and working in the other direction, the above method assumes that the whole of the growth in the concessionary market over the last few years is due to price change effects and none to service quality change effects. We accept that in principle there is a case for adjusting for service quality effects (principally service frequency/vehicle kms and proportion of low floor buses) if suitable data and elasticities can be found.

55. The results in table 1 are based on 2005/6 fares and values (average full fare £1.12 for the Mets and £1.20 for the Shires) with an assumed uplift of 2% per annum real to get to 2008/9. They could be rebased to a particular value such as £1 at 2005/6 prices if that was considered to be preferable. If a more recent baseline is required for the Guidance, it would be necessary to adjust the average real fare from 2005/6 to say 2009/10 values and then recalculate the elasticities and RFs corresponding to the more recent real fare level. An appropriate fare or average revenue per trip series would then be an important priority for the Department.

Additional costs

56. Alongside the work on demand elasticities, some analysis has been carried on bus operator costs, in order to obtain estimates of the additional cost of carrying the generated concessionary passengers due to the ENCTS.

57. Terminology used in reimbursement breaks costs down into two categories, 'marginal costs' and 'additional capacity costs':

    - marginal cost – the cost to the operator of carrying an additional passenger given fixed capacity,
    - additional capacity cost – the cost of providing additional capacity to accommodate the increase in demand for bus travel where necessary.

58. Marginal cost was estimated using evidence from: (i) a new econometric model of bus operator costs, based on STATS100 and TAS data for the period 1999-2007; (ii) past claims and settlements; and (ii) evidence on the sub-components of marginal cost such as fuel and

insurance. The three approaches give results which are broadly consistent and we recommend a mean value per generated passenger trip outside London of 7.2 pence (at 2009/10 prices). This is composed of a fixed element, 4.2 pence, and a variable with distance element, 0.5 pence per km.

59. Additional capacity cost was estimated using evidence from: (i) the econometric model of bus costs; (ii) accounting cost models of the CIPFA type; and a range of other evidence which is required in order to complete the analysis. In this case the results are subject to assumptions and caveats, and need to be viewed as broad-brush working estimates, which will be improved upon by future research.

60. The new econometric modelling results indicate that the additional costs per bus km and per peak vehicle are as follows (at 2009/10 prices):

- £0.53 per bus km (95% confidence interval £0.32 to £0.75);
- £17,900 per peak vehicle (95% confidence interval £12,300 to £23,500).

61. Vehicle hours are omitted from the model due to lack of available data. This is regrettable since there are as a result judgements to be made about how much of the vehicle hours costs are being picked up by other terms in the equation. We advise that the Department begin gathering vehicle hours as part of STATS100A to enable more complete modelling in future.

62. For the time being, the following parameters are assumed, based on an overview of the evidence. An adjustment has been made to the vehicle km parameter following the inclusion of the vehicle hours parameter, i.e. recognising that the cost per vehicle km might be lower than the central value of £0.53 above and thus perhaps lie in the range £0.30-£0.53. As a sensitivity test, the econometric model results were also used alone giving a vehicle hour parameter of zero and the other two parameters as above – this case cannot be ruled out based on the econometric evidence, although it is at odds with the accounting models in use.

- £14.90 per additional vehicle hour; plus
- £0.30-0.53 per additional vehicle km; plus
- £17,900 per additional peak vehicle if relevant (see para 66 below)

63. These costs per unit of supply need to be mapped on to a relationship between demand generated by the scheme and supply response. There are various approaches including case studies and simulation which could be used. In our work, to represent bus operators' adjustment of service frequency to increased patronage, a simple relationship was assumed:

$$\frac{F_1}{F_0} = \left(\frac{q_1}{q_0}\right)^{0.6}$$

where *F* is frequency and *q* is patronage.

64. When frequency is increased, there is a second-round effect on demand through the perceived increase in service quality. This was modelled using a long-run service elasticity value of 0.66 (consistent with Black Book 2). It is appreciated that the value for this elasticity is a point of controversy but our view is that this is a reasonable overall average value to use in this context.

65. Taking these relationships into account, some indicative calculations were made for two route types: 'PTE' assuming an average speed of 14.1kph including turns and a route length of 10km; and 'urban non-PTE' assuming an average speed of 16.1kph and route length of 11.5km. The additional capacity cost net of revenue gain per additional concessionary passenger was provisionally estimated to be 15-22 pence (PTE) and 17-25 pence (urban non-PTE), although the results are sensitive to underlying assumptions. The results are found to compare reasonably well with the approximate additional cost per passenger of meeting increased demand by running larger vehicles, which we estimate to be of the order of 15-17 pence per additional passenger.

66. Some important caveats and limitations remain:

- These additional capacity costs per passenger exclude the costs of additional peak vehicles, i.e. they are the incremental net cost per passenger of running a given fleet more intensively. The question of a peak vehicle requirement (PVR) cost was examined using a number of different peak/off-peak demand profiles. Overall we are not persuaded that large network operators are usually required by the scheme to operate with a higher PVR than in the absence of a scheme.

- These are not detailed route-by-route estimates of operator response to the ENCTS. In practice, some routes will see step changes in frequency, whilst others will require no increase in frequency to accommodate the additional concessionary passengers. These are broad aggregate average estimates.

- Operators may operate a 'flat' profile of service frequency across the day for reasons other than matching demand to capacity per service. These reasons include: labour cost structures (e.g. the split shift premium – the hourly cost of drivers' labour may be increased by the inclusion of a break in the middle of the working day); passengers' preference for simple and predictable timetables; and the difficulty of varying vehicle size between peak and off-peak periods. A simulation including all of these factors could provide valuable further evidence, but was beyond the scope of the data and method used in this study. We are aware that both operators and consultants have undertaken work of this style.

67. It is suggested that these marginal cost and additional capacity cost estimates are suitable as average estimates for major bus groups at least, and for smaller operators where the demand profiles we have considered are applicable. Exceptional cases are those where it can be demonstrated that the Peak Vehicle Requirement has increased as a result of the ENCTS. This will depend on evidence for the operator's route network as a whole.

68. The approach to dealing with additional costs essentially assumes a commercial environment. That is, the operator, faced with x per cent more traffic than in the absence of the scheme, determines their commercial response. Where the service is secured through Minimum Gross Cost tender, we consider that the issue of additional cost does not arise. Where the service is secured through Minimum Subsidy or Net Cost tender, the authority is determining the capacity it wishes to see provided so that additional capacity costs are covered through the tender process. However, we think that in this case the operator should be reimbursed for the marginal operating cost of carrying additional passengers on that secured capacity.

Conclusion

69. This paper, taken with the supporting Annexes and Research Papers is intended to provide advice to the Department for the forthcoming consultation on changes to the Guidance on Concessionary Reimbursement. It covers the work of the research team on three key elements of reimbursement, namely the relevant fare, the demand curve and elasticity, and the costs of carrying additional passengers.

70. Although not strictly within our terms of reference, we have naturally had some thoughts about how the research results should be used in practical application. We believe that, following review of the illustrative numbers in this paper, the system will best be served by the framework being mandatory and the Guidance values having strong default status. That is, evidence will need to be of a high standard to warrant a local departure. On the other hand, it is accepted that the evidence base is strongest for urban England and relatively weak for deep rural areas.

71. We would envisage the framework being applied across operators and areas at a point in time and also to roll the system forward in time as real fares change. Thus if operator X has an average fare which is z% higher than operator Y, the relevant point elasticity for X would be higher and the RF lower than for Y. If operator X's real fare rose from year 1 to year 2 by p%, the corresponding point elasticity would rise and the RF would fall (but with demand inelastic, the sum reimbursed per concessionary trip would rise though by less than the fares increase).

72. For practical reimbursement, there are many choices surrounding the construction of the local fare indices, the trip volumes by fare/distance band, whether to fix the elasticities and RFs annually, whether and in what circumstances to allow retrospection to cover variances between forecast and actual fare levels and how to handle changes in fares and RFs during multi-year agreements. Guidance can be provided on these matters but local discretion on implementation is appropriate.

August 2010

Annex A – Digest of Research Papers

Research Paper 1 – Economic Principles Underlying Reimbursement

The current approach to concessionary fares reimbursement in England, outside London, was established by the 1985 Transport Act and associated Regulations. Since the 1985 Act, the guiding principle for reimbursement has been that operators should – so far as is reasonably possible – be reimbursed so that they are 'neither better nor worse off' as a result of the concession.

In the late 1980s and early 1990s, many Travel Concession Authorities (TCAs) were operating relatively modest local schemes such as a half fare off-peak, for which it was possible to agree a generation factor[6] of say 25% (see for example Mackie and Preston (1996), Hill and Last (1993), Balcombe *et al* (1998)). Since 2000, the introduction and gradual enhancement of national minimum standards for concessionary fares has resulted in:

- higher generation factors;
- an increasing proportion of concessionary trips in total local bus trips, and concessionary reimbursement becoming a greater proportion of total operator revenues;
- greater difficulty estimating the appropriate reimbursement, as the current fares and patronage move further away from their equilibrium levels without a scheme – and as the data for relatively modest schemes become more and more historic.

Clarity about the calculation of reimbursement is therefore particularly important at this time. First, calculation of revenue reimbursement requires an understanding of the demand response to changing concessionary fares. Key issues on the demand side are:

- *Demand functional form.* Previous research suggests alternative functional forms, including: constant elasticity functions; proportional elasticity and other negative exponential functions; and linear demand functions. Therefore a key task is to investigate the most appropriate form, and any necessary parameter values, in the light of the new evidence and the existing body of knowledge (see Research Paper 4).
- *Elasticities.* Knowledge of elasticities at full fare, and elasticity variation with fare and other factors, are important in specifying the demand response (Research Papers 5-8 will provide elasticity evidence).
- *Short-, medium- and long-run adjustment.* Previous evidence from Dargay and Hanly (1999), indicated that the short-run elasticity (after one year) is approximately half the long-run elasticity (after five to ten years) in the bus market. This is revisited in Research Paper 4.
- *New passholders.* An exception to the pattern of lower elasticities at lower fares has been the introduction of free concessions in April 2006, which has produced increases in trip making in excess of what would be predicted using elasticities estimated at half fare. A useful approach is therefore to segment the market into 'existing passholders' (I) and 'new passholders' (see Research Paper 5).
- *Fares.* Demand for bus travel comprises demand by older and disabled people ('eligible individuals'), and demand by all other groups. Since age and disability are objective characteristics of the individual rather than choice variables, it is reasonable to treat these

[6] net generation factor defined as: $(Q_1-Q_0) / Q_0$ where Q_1 is the quantity of quantity of concessionary trips made with the scheme in place; and Q_0 is the quantity of trips made by the same people without the scheme in place.

demands as additive. The fare structures faced by each group are different, as are the average fares (see Research Paper 2).

Reimbursement for additional costs requires an understanding of the cost structure of the local bus industry. The starting point is the literature review, which identified accounting models of the 'CIPFA' type as the prevalent tool for bus modelling. This study has also undertaken some original econometric analysis of bus costs using STATS100A data, which allows us to obtain an up-to-date assessment of the marginal costs of additional passengers. It also provides an assessment of the additional costs when the service pattern changes, albeit with uncertainties (Research Paper 9).

Finally, reimbursement options include a single reimbursement rate, a table of rates, or an improved status quo. Participants and consultees have suggested a number of ways in which the current arrangements could be improved have been suggested by, including:

- simplification;
- clarify issues over demand elasticities and functional form;
- providing the parties with more information and tools for estimating additional costs.

Research Paper 2 – Issues relating to Average Fares

In order to estimate revenue foregone relative to a no-scheme counterfactual, it is necessary to make a forecast of the fares structure and of the pattern of ticket type choice by those eligible in the absence of a scheme. It is argued that in the counterfactual, operators would be likely to increase the peak/off-peak fare ratio and/or segment the market. Evidence is provided of current marketing initiatives (for example special fares for college students), and of difficult competitive conditions (for example rail served corridors in PTE areas).However, it is acknowledged that without stronger evidence on relative elasticities of market segments, it is not possible to make a firmly based prediction of how the fares structure and level would change in the absence of a concessionary scheme. We therefore assume that the commercial fares structure and level are independent of the concessionary scheme.

Given an assumed fares structure, the next crucial question is how eligible people would allocate themselves to the different fares in the fare basket. It is shown that in the commercial market, the proportion of one day and period tickets in total commercial travel has increased appreciably in recent years. Good data on trip frequency by concessionary passholders has been difficult to obtain; this is a necessary input to prediction of the market shares of different ticket types. One source is the NoWcard data from four districts of Lancashire. This shows that the 3% most intensive bus users make 10 plus bus trips per week and account for 25% of bus trips by passholders. A further 50% of bus trips by passholders are by people making over 3 to 10 trips /week (average over 5 week period). Further data is available from analysis of the Nottingham card (see below). We believe the trip frequency distribution is generally applicable to urban England.

Two methods are proposed for calculating the average fare which is applicable to the concessionary traffic in the absence of a scheme. The first is a detailed calculation of the frequency distribution of trips with the trip rates suitably abated to allow for the 'de-generation' which would occur in the counterfactual. In the absence of solid evidence, we advise assuming that all trip frequencies shrink proportionately. This distribution, based on NoWcard data as an example, is then applied to actual fare structures offered. The advantage of this method is that it takes proper account of the different marketing strategies and ticket type market shares which are to be found. For example some operators price their day and weekly tickets to be attractive to much of their market while others aim these products at the longer distance end of the market. The method permits the trip frequency distribution and the ticket pricing structure to be considered together. An illustrative spreadsheet is provided.

A second method is a cut-down version of the first for use where TCAs and operators were able to agree that average concessionary fare would be computed as average revenue per adult trip (ARAT), computed on the basis of commercial ticket type market shares and assumed trip rates using one day and period tickets. This could be more appropriate for TCAs with relatively small concessionary budgets and/or in rural areas, and for all TCAs in their dealings with small operators.

The outcome is clearly dependent on passholder travel patterns and operator ticketing strategies. On the basis of evidence we have seen, we expect the relevant 'discount' from cash (weighted average single and return) revenue per trip to the relevant average fare for reimbursement purposes to be of the order of 8-12%. This is equivalent for example to 40% of the concessionary travel in the absence of a scheme being made on a day or period ticket attracting a discount of 20-30% to the weighted average single/return fare. The resulting average fare should be the measure of 'full fare' to which the elasticity is tied in computing revenue foregone.

Research Paper 3 – Analysis of Concessionary Passholder data from Lancashire and Nottingham

The analysis reported here provides descriptive statistics about a subset of older and disabled concessionary passholders in Lancashire and Nottingham, as recorded by smartcards in the spring and summer of 2009.

The data demonstrates that the use made of the statutory concessionary pass varies enormously. It confirms that great care needs to be taken in interpreting aggregate statistics, and average characteristics of passholders and their travel behaviour, because of the skewed distribution of trip frequencies that will underly such averages.

Caution is clearly needed in applying results from this analysis to a different geographical context. However, it seems likely that many of the characteristics identified here regarding the extent of variation between passholders and their concessionary travel will apply elsewhere, although the absolute magnitude of figures will no doubt vary from area to area. Similar analysis of data from elsewhere would be extremely valuable in confirm the generality of some of the results quoted, particularly from a rural area.

Key findings from the Lancashire data are that:

- On average, 1.34 concessionary bus journeys per week were made per passholder in the period for which data was available;

- However, a majority of passholders made no bus journeys using their concessionary pass in this five week period;

- Fewer than 15% of passholders made more than 75% of all concessionary trips and fewer than 2.5% of passholders make 25% of all trips;

- Passholders aged less than 60 (and who are therefore entitled to the pass on grounds of disability) make more use of the pass than those aged 60 or more: average weekly trip rates for these groups of passholders are 3.57 and 1.23 respectively;

- The average trip rates of older passholders vary somewhat by age (ranging between 1.03 and 1.44); there is much greater variation by age amongst passholders aged less than 60, with the largest trip rates being for passholders aged between 30 and 45;

- Average trips rates vary by type of area; passholders in larger urban areas make on average ten times the trips per week of those living in areas characterised as “sparse hamlets and isolated dwellings”, although there are relatively few passholders living in the latter type of area represented in the dataset;

- Proportions of non-user passholders vary similarly between area types. Even in larger urban areas non-user passholders account for 50% of the total of passholders;

- The average trip rate of previously eligible passholders, who obtained a pass after the introduction of the English National Concession in April 2008, is half that of similarly aged passholders who had obtained a pass previously; this ratio varies between area types, from about 54% in urban areas to 21% in hamlets and isolated villages.

- The data allows the potential take up of discounted ticket types such as daily or weekly tickets to be examined, although inference of commercial discount rates requires further analysis and various assumptions.

Findings from analysis of the Nottingham data are similar in many respects, particularly in terms of the distributional characteristics that are so striking. However, the overall rate of concessionary bus use is much greater in Nottingham, with an overall average trip rate of 2.45 bus trips per passholder per week, and there are indications that the relatively small proportion of frequent users in Nottingham is both somewhat larger and makes more use of the bus than the equivalents in Lancashire. But in both areas around 50% of passholders make virtually no use of the concession for bus travel. It would be particularly useful to understand how much non-use of the concession is associated with poor levels of bus accessibility, since by implication other reasons for non-use are likely to arise from the socio-economic characteristics of the passholder.

There remains considerable scope for further analysis of both datasets. All the results summarised above come from the examination of trip making by passholders aggregated over weekly periods. More could be done with the data at this level, including:

- Further tabulation of trip rates (and potentially take up) by additional geographical characteristics such as bus accessibility and socio-economic data.

- Disaggregate analysis of the trip patterns to obtain estimates of potential discounted ticket market shares for combinations of discounted ticket types and relative prices;

- Review of these results in the wider context provided by the NTS data set, and other research sources providing insights into older and disabled people more generally (e.g. employment rates by age).

In addition, the data could be examined at the level of individual trip characteristics, since in principle information is available regarding trip start time, journey length, stated fare, and possibly other geograohical features that could be related to the captured transaction data. However, this represents a significant additional task in terms of data preparation and analysis.

Research Paper 4 – Shape of the Demand Curve

This paper was commissioned from Professor Phil Goodwin of UWE and was developed in conjunction with Andrew Last of Minnerva. It considers the properties of a demand curve which would be used for estimation of the level of demand that would apply in the absence of a concessionary fare scheme for the elderly.

The nature of the problem is that this calculation involves extrapolation to conditions in which there is no recent direct empirical evidence, so recourse has to be made to theoretical and logical argument, direct inference from old information, and indirect inference from more recent information.

A range of different demand curves are discussed, including linear, exponential, and constant elasticity forms. These differ crucially in their assumption about how elasticity varies with the level of real fare. The exponential form is also modified into a more general form (the 'damped exponential') in which an additional parameter allows fares to have a greater or smaller effect on the elasticity. With less damping, there is a greater difference between the observed demand with the concession, and the estimated demand without the concession, all other things being equal.

There is an inter-relationship between all the parameters that determine a particular functional form and the implied elasticity values. In particular, if a damped exponential model is to be the preferred functional form, then ideally both the damping factor (Lambda) and the Beta factor (which in the undamped form is the "Proportional Elasticity constant") should be determined jointly from the empirical evidence. In the absence of strong evidence about the size of the damping factor, and the need to make an a priori judgement about it, it must be recognised that this then inevitably constrains the resulting full fare elasticity if the Beta value is estimated from data at the low fare end (e.g. from the change to free fares). Consequently, a judgement on damping factors cannot be made without reference to the implied full fare elasticities, and their relationship to the "zone of reasonableness" of such values established from the wider body of research evidence.

Quantitative evidence is then examined drawn from simulation, consideration of generalised cost, local practice and national guidance in recent and more distant years, the history of results of elasticity estimation since 1960, empirical results from specific studies, the results of the move to free travel in seven counties and 4 PTEs, and two new analyses carried out by ITS for this project.

Goodwin and Last both recommend the use of a damped exponential as the 'core' relationship to be used in estimating the demand that would apply in the absence of a concessionary fare scheme. Last would support a damping parameter somewhere between 0.7 and less than 1, without confidence that the evidence base supports any particular number in that range. Goodwin would propose a damping parameter in the range 0.5 to 0.7 with a preference for 0.6.

Goodwin supports an associated short term full fare elasticity, which is probably less than that of the adult market (so could be about -0.3 at the fare levels to which the evidence base relates) and suggests a long-term uplift of the order of 30% to 50% over the short term (one year) elasticity. Last does not have a recommendation on the associated value of the short term or long term full fare concessionary elasticity, because the full range of arguments and evidence has not been considered by him, particularly with regard to the issue of how elasticities appropriate to the concessionary market relate to those for other markets.Both authors observe that the point of overlap in views on the size of the damping factor is at 0.7,albeit noting that this does not of itself prove that figure is right, or change their separate assessments.

Research Paper 5 – Elasticity Estimates from PTE and MCL Datasets

It is natural to study the CT market at area level. There is no a priori reason to suppose that demand for bus travel has the same elasticity characteristics in metropolitan and small town England, although we would expect there to be similarities in elasticity values for areas in which geographical and socio-economic characteristics were similar. Moreover, since TCAs are local government entities, there is a need for results to be capable of application at local area level.

There are a number of preliminary remarks to make about area data:

Outside the PTEs, TCAs themselves are not large well-staffed organisations. They are run by officers often with a range of other responsibilities who since 2006 have become responsible for much bigger budgets and operating in more strongly contested territory.

The data TCAs have on trip volumes and fares is as good as the quality of the raw material, for which, by-and-large, TCAs are dependent on what is supplied by local bus operators.

The quality and consistency of the reporting in the DfT TCA survey is problematic. One of the main reasons for this is the variety of concessions provided by individual TCAs, and in particular alternatives to the statutory concession (such as travel tokens) which can be very significant in some areas.

Even the best area data requires manipulation and interpretation to be usable in our context. Examples are the need to distinguish between 'new' and 'old' passholders and the need to allow for the change in April 2008 in the definition of trips for which a TCA is responsible for reimbursing from trips made by 'their' passholders in 'their' area to trips originating in 'their' area made by all passholders. This change in definition makes area data for 2008/9 particularly difficult to interpret, equivalent to a change in the series.

The need to distinguish between new[7] and 'old' passholders stems from the need, for the purposes of elasticity estimation, to measure the demand for bus travel by eligible people rather than the demand for concessionary travel. It is essential, as far as possible, to control for 'ticket type diversion' from commercial to concessionary as the CT scheme has become progressively more generous. However, commercial tripmaking by eligible people cannot be distinguished in data from other commercial trips. We believe that much the most important thing to control for is the increased propensity to pass take up as the scheme has become more generous. To do so, it is necessary to allow for differences in trip rates between 'new' and 'old' passholders. No allowance has been made in our work for the effects of changes in the scheme on diversion between pre 0930 commercial and post 0930 concessionary tripmaking.

Andrew Last of Minnerva was commissioned to look much more closely at data for the six English PTEs and at data for seven countywide schemes administered on the TCAs behalf by MCL, to whom we are grateful and who devised the methodology for dealing with different typesof new passholders. This data covers the four years 2005/6 to 2008/9. By its nature, these data provide a good picture of what has happened in Metropolitan England and the southern Shire counties but not the unitary authorities or the midland and northern shires.

For the PTE area analysis, data issues and uncertainties are less significant than for elsewhere, although there remain issues associated with new passholders. However, the best evidence suggests that increases in passholders have been relatively muted in the PTE areas (e.g. with an average 17% increase from 2005-6 to 2008-9), and elasticity estimates are therefore less sensitive to how these are allowed for.

Headline changes in the four PTEs that became free in April 2006 are:

- Overall concessionary trips increased by 25%, 32% and 42% from 2005-6 levels in each of the years;
- Trips by "old" passholders increased by 24%, 28% and 34%;

[7] 'New' passholders are those induced to take up a pass by the increased generosity of the scheme from April 2006 onwards.

- The point fare elasticities calculated from the change in each of these years are -0.548, -0.612 and -0.728 if measured at a fare of £1 in 2005-6 prices, or -0.649, -0.733 and -0.886 if measured at the full fare in each year. These elasticities assume an un-damped proportional elasticity model. Elasticities calculated from alternative models will be different, and in particular if damped proportional elasticity models are used, point fare elasticities are lower.

The situations reflected in the MCL Shire county datasets are much more complex than those in the PTEs, because the membership of some county-schemes has varied over the years, and each TCA has been able to specify discretionary concessions either additional to or instead of the statutory concession, which may also vary from year to year. In addition, increased pass-take up of the statutory concession has been much more significant, in some instances with pass numbers trebling between 2005-6 and 2008-9. In addition, 2008-9 trips in these areas are likely to be more affected by the shift in reimbursement responsibilities between neighbouring authorities. A scheme-specific series of adjustments have therefore had to be devised by MCL to allow like-for-like comparisons to be made between the years. There remains greater variety in the Shire county results than is the case with the PTEs, partly reflecting residual uncertainties about the factors that vary between schemes.

Headline changes in the seven Shire counties for which MCL provided data are:

- On average, a doubling of concessionary trips between 2005-6 and 2008-9, and a doubling of passholder numbers;

- On average, increases in “old” passholder trips from 2005-6 of 37.9%, 47.1% and 45.3%. The slight reduction in trips in 2008-9 (which would imply a fall in elasticities, contrary to expectations) may be symptomatic of uncertainties associated with the comparability of 2008-9 trip data and that for earlier years, specifically the effect of the change in responsibility for trip reimbursement referred to above;

- The point fare elasticities calculated from the change in each of these years are -0.537, -0.644 and -0.624, if measured at a fare of £1 in 2005-6 prices, or -0.724, -0.835 and -0.874 if measured at the full fare in each year. These elasticities are as defined above.

- There is much greater variation in the elasticity values around these averages, with (for example) 2006-7 point elasticities at £1 in 2006-7 varying from -0.338 to -0.635.

Research Paper 6 – Analysis of The National Travel Survey Data

Trends in bus travel and concessionary pass-holding are examined using NTS for 1995 to 2008. Only individuals eligible on grounds of age are considered, due to small sample sizes for those eligible on grounds of disability.

Total bus journeys by eligible individuals fell by around 10% over the period, while journeys using a concessionary pass rose by around 25%. Passes were used for around two-thirds of bus journeys before 2001 to well over 90% today. Over the same period mean trip length rose 24%. There are significant differences amongst areas. In London and the Mets, total bus trips by eligible individuals have fallen by around 14% and 16%, respectively, while in the Shires there was an average increase of 6%. The proportion of journeys using the pass increased in all areas, but more so in the Shire counties than in more built up areas.

In England as a whole, pass-holding grew from under 50% of the eligible population before 2001 to 73% today – an increase of nearly 50%. There are, however, substantial differences amongst areas, ranging from 14% growth in the Mets to 70% on average in the Shires. In 2001, pass-holding was nearly 3 times as high in the Metropolitan areas as it was in rural areas, whereas today the difference is only 50%. It is evident that pass-holding has increased more in areas with relatively low initial rates of pass-holding, reflecting differences in the initial schemes.

Car availability and driving licence holding are amongst the most important factors determining differences in bus use between individuals. Trip rates for individuals in non car owning households are about 5 times those for individuals in households with cars, while trip rates for those without driving licences are over 3 times those with licences.

Car ownership and licence holding for eligible individuals have changed considerably over the period. Car ownership increased from 60% to 75% and licence holding from 49% to 67%. In this respect, individuals eligible for concessionary travel owing to age have become more similar to non-eligible adults. For example, in the Mets, car ownership for eligible individuals increased from 48% to 65%, while for non-eligible individuals car ownership remained the unchanged at 80%. For the Shires, the increase was from 68% to 78% compared to a constant 90% for other adults.

In terms of car availability and licence holding, concessionary bus users have also become more similar to non-concessionary adult bus users. Car ownership amongst concessionary bus users was only about two-thirds that of non-concessionary bus users in 2001, while there is only a negligible difference today. For licence-holding, a similar convergence is noted.

Although it used to be argued that concessionary travellers were more captive to bus than other bus users, this has changed in the last decade and now concessionary travellers are similar in key characteristics to other bus users. Because of this, we think the off-peak elasticities of both groups are likely to be similar.

Using the NTS combined with TCA data on local concessionary schemes, an econometric model was estimated to disentangle the effects of the introduction of the free travel scheme from the impact of other factors affecting bus use over the period 2001 to 2008. From the modelling, we conclude:

- As expected, free bus travel results in greater bus use than half, flat and hybrid fare schemes, but no consistent significant differences could be found for the time of validity and geographic coverage of the scheme.

- Car ownership and driving licence holding are confirmed to be amongst the most important determinants of bus use. Other contributing factors are age, income, distance of residence from bus stop, bus frequency and area of residence.

- In the counterfactual without free travel, total bus trips by eligible individuals would have declined by 3.0% per annum in the Mets and 1.6% per annum in the Shires. This is almost entirely due to exogenous growth in car ownership and driving licence holding.

- The model predicts that free fares had the effect of increasing bus travel by eligible individuals in 2008 by 26% in the Mets and 45% in the Shires relative to the counterfactual. This is equivalent on the assumption of an undamped proportional elasticity model to a full fare elasticity of -0.47 (Mets) and -0.75 (Shires). This elasticity represents the change after 2 years; over time we would expect the elasticity to be greater.

Research Paper 7 – Survey of Concessionary Travellers

A telephone survey of people aged 60+ living in England outside London was conducted in August 2009. 7161 respondents had made a bus trip within the last seven days and were deemed 'in-scope'. These respondents were asked questions about when and why they got a pass, about their use of buses, about their socio-economic status and then asked to give some details of the trips made on the last day they had used a bus. A further 2511 individuals who had not made a trip in the previous seven days were asked some general questions about their bus use.

The survey was intended to generate:

- Data on holding and non-holding of bus pass by person-type/area type

- Data on use and non-use of bus by person/area type

- Data on out-of area trip making

- General terms comparison of pre- and post-national scheme

- Then some specific trip information:
    - Time of day
    - Trip length (proxied by duration)
    - Purpose
    - Willingness to pay (via stated intention)

General usage of buses was calculated by ascribing a notional number of trips to a stated frequency of use. Thus, someone who said they used the bus on six or seven days a week was assumed to make trips on 338 days at the rate reported in the diary.

'Old' passholders – that is, those who held a pass prior to April 2006 – make the most trips: 352 a year.

New pass holders who got a pass as soon as eligible make more trips than those who waited a while to get one : those obtaining a pass as soon as eligible between April 2006 and March 2008 made 320 trips, whereas the others made 239 trips. From April 2008, those who got a pass as soon as eligible made 339 trips, while those waiting a while made 268.

Other findings arising were:

- The gap between those who have had a pass a long time/got one as soon as eligible and those who elected to get a pass some time after becoming eligible closed somewhat with the move to national concessionary fares scheme. If this continues, the old/new passholder distinction will soon become irrelevant.

- There is about 20% growth in travel before and after April 2008, which must at least in part be due to the national scheme.

- Most of the absolute growth in total commercial and concessionary trips is within the boundaries of the previous scheme[8]. Out of an average 51 more trips being made after April 2008, 45 were made 'in district' – where the national scheme has had no effect on eligibility - and 6 outside.

- Metropolitan areas showed lower growth (12%) than non-metropolitan (22%).

[8] Data from the survey suggests that around 93% of trips by passholders are made in the post morning peak time period when eligible for the national concession.

- There is variation in regional growth from over 20% to about 13% but this variation appears generally unrelated to pre-existing trip levels.

- The 7161 respondents reported details of 13704 trips in their one-day 'diaries'. As well as trip details, respondents were asked to indicate if they would have made the trip at full fare or at half fare.

- Very few trips before 09.30 –only 7.1% of all trips being made at this time.

- Very few work trips – With only 1.6% being made for this purpose.

- Models were estimated using the responses about whether a given trip would have been made at half fare or full fare. The elasticities from these models reported here are point elasticities at full fare based on a linear demand curve.

- There is the expected variation in WTP/elasticities according to use, purpose, employment status & income.

- More frequent users (2 or 3 days a week or more) have a smaller elasticity (-0.65) than less frequent users (-0.85)

- Non-discretionary trips (work/personal business) have smaller elasticities than discretionary trips

- Those with car available all the time had an elasticity of -1.24, compared with -0.48 for those with lesser availability/no car.

Headline full-fare elasticity from this survey is -0.7. It is possible that some stated intentions bias exists and, if so, this could lead to an inflated value, however this remains unproven.

Research Paper 8 – Market demand elasticity variation using STATS 100A database

The STATS 100A database contains data by operator over a number of years on passenger trip numbers, passenger revenues and vehicle-km. This data supplemented by population and other demographic data and motoring cost data from other sources, allows for total demand for bus trips per capita to be explained by average revenue yield per trip, service frequency, motoring cost and proportion of population that are pensioners. Importantly, no data is available on the split of either revenue or trips by concessionary passengers and non-concessionary passengers. Thus the main modelling is for the whole market, that is, the sum of concessionary and fare paying travellers.

The analysis provides estimates of fare, income and service frequency elasticities of correct sign, however these magnitudes are below those found in the previous studies, most notably Dargay and Hanly (1999) which undertook similar analysis on the STATS100A data but for a shorter sample period. This work indicates that the short run fare elasticity at average fare across the whole market is of the order of -0.2 to -0.3 while the long run fare elasticity is approximately -0.4 to -0.5. This compares with Dargay and Hanly's estimates of the short run fare elasticity between -0.3 and -0.4 and long run elasticities approximately twice this.

The analysis reports strong evidence that the whole market fare elasticities are falling over time. For 2006/07 specifically an estimate of -0.2 and -0.35 for the short and long-run whole market fare elasticities is indicated from the results.

There are strong a priori reasons for the estimated whole market fare elasticities being lower than those found in previous studies. This is because:

- There has been an increase over time in the proportion of passengers paying fixed or zero fare.

- These passengers will have no reaction to changes in the fare level given they pay an unrelated charge (or none at all).

- The measure of fare in this study is average fare box revenue yield per passenger which includes both concessionary and non-concessionary passengers. This will therefore represent neither the trends in concessionary fares (which have fluctuated over time in the period from 1988 to 2005) nor the trends in non-concessionary fares (which have increased)

- Since concessionary patronage has increased as a proportion of total bus trips, coupled with the move to flat (or zero) fares for this group, it is no surprise that calculations of elasticities from the sum of concession and non-concession passengers imply rather little sensitivity to changes in fares.

Unfortunately, it has not proved possible within the STATS 100A dataset to decompose the whole market into its concessionary and fare paying constituents. However, the authors have illustrated how this could be done using data on real fares and travel values for concessionary and fare paying traffic in the six PTEs for the period 1998-2003. It should be emphasised that in this particular period, fares in both sub-markets rose.

The illustration shows an average 1998-2003 full fare short-run elasticities for farepaying traffic for the PTEs of -0.32 which is in line with previous findings. It may be possible to look at the STATS 100A data for 2007/8 and 2008/9 now that is has become available; these are years in which the farebox revenue does not need to be split between concessionary and fare paying traffic.

Research Paper 9 – Additional Costs

This report describes the estimation of the *additional costs* to bus operators, as a result of carrying generated concessionary passengers under the English concessionary travel scheme. A useful way of breaking this down is to examine 'marginal costs' and 'additional capacity costs':

- *marginal cost* – the cost to the operator of carrying an additional passenger given fixed capacity, which is fairly small;
- *additional capacity cost* – the cost of providing additional capacity to accommodate the increase in demand for bus travel where necessary.

Marginal cost is estimated using evidence from: (i) a new econometric model of bus operator costs, based on data for the period 1999-2007; (ii) past claims and settlements; and (ii) evidence on the sub-components of marginal cost such as fuel and insurance. The three approaches give results which are broadly consistent and we recommend a mean value per generated passenger trip outside London of 7.2 pence (2009/10 prices). This is composed of a fixed element, 4.2 pence, and a variable with distance element, 0.5 pence per km.

Additional capacity cost is estimated using evidence from: (i) the econometric model of bus costs; (ii) accounting cost models of the CIPFA type; and a range of other evidence which is required in order to complete the analysis. Costs are updated to 2009/10 for comparability. The new econometric modelling results indicate that the additional costs per bus km and per peak vehicle are as follows, although vehicle hours are omitted from the model due to lack of available data:

- £0.53 per bus km; and
- £17,900 per peak vehicle.

When capacity is increased by raising service frequency, there are additional costs associated with increases in the number of vehicle kms and vehicle hours operated. These costs have been estimated using the results from modelling approaches (i) and (ii) – there are some differences in the additional cost estimates depending upon the approach taken.

Also when frequency is increased, there is a stimulus to demand from the reduced waiting time and perceived improvement in service quality. This gives rise to an operator revenue increase – a point recognised in principle by operators in their own analysis, although the results differ for reasons that are reasonably clear, e.g. the use of different elasticity values. Each increase in demand then prompts a reaction in frequency and vice-versa, leading towards a new equilibrium. We use a relatively simple Mohring-type model to represent this interaction between bus patronage and frequency. Although it works at an aggregate level for a representative bus route type, this model has some advantages over the very detailed simulation approaches which have been used recently in the industry. In fact, we believe the two could be made consistent, if certain key differences in assumptions were addressed.

Taking these relationships into account, some indicative calculations were made for two route types: 'PTE' assuming an average speed of 14.1kph including turns and a route length of 10km; and 'urban non-PTE' assuming an average speed of 16.1kph and route length of 11.5km. The *additional capacity cost net of revenue gain* per additional concessionary passenger was provisionally estimated to be 15-22 pence (PTE) and 17-25 pence (urban non-PTE), although the results are sensitive to underlying assumptions. (If the cost term per vehicle hour is zero – and this cannot be ruled out based on the econometric evidence alone – the additional capacity costs turn negative, -9 pence and -7 pence respectively). The results are found to compare reasonably well with the approximate additional cost per passenger of meeting increased demand by running larger vehicles; if that comparison is used to fix the cost parameters then the lower end of the ranges above will be the cost estimate that is 15 pence and 17 pence respectively.

These costs exclude the costs of additional peak vehicles, in other words. they are the incremental net cost per passenger of running a given fleet more intensively. Also, they are not detailed route-by-route estimates of operator and consumer behaviour, but broad aggregate average figures.

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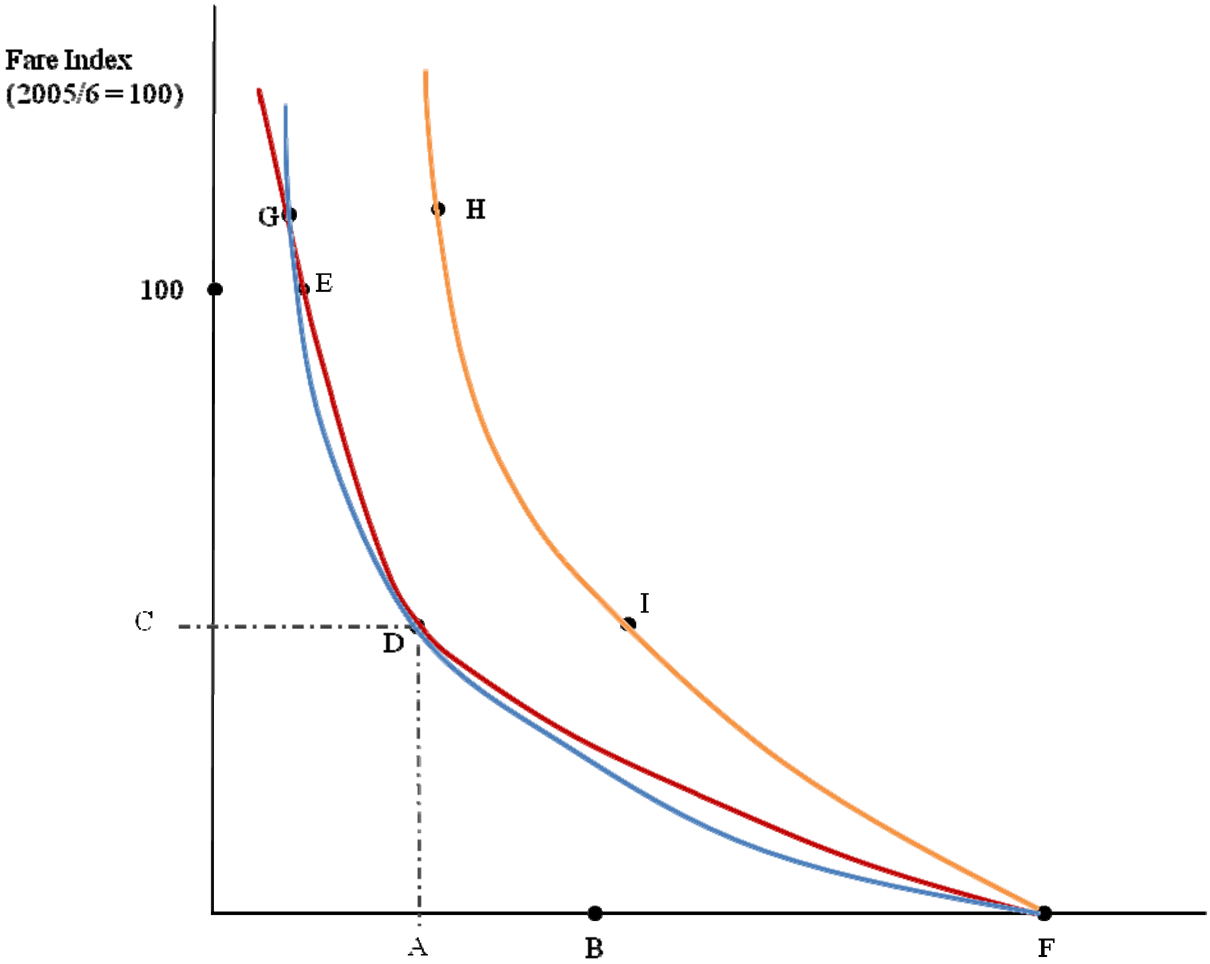
Annex B: Construction of the Single Demand Curve and Calculation of Reimbursement Factor.

<u>The concept</u>

Using the logic and evidence described in paragraphs 39-55, a framework has been developed for estimating the reimbursement factor using a single demand curve.

We use data from the analysis of PTEs and Shires (summarised in paragraphs 18 to 21 of this report and taken from research Report 5) and our knowledge of concessionary elasticities (summarised in paragraphs 25 to 38 of this report, and drawn from research Reports 4 to 8) to estimate a curve between a zero fare and a concessionary fare.



A: old passholder counterfactual volume 2008/9 at 2005/6 concessionary fare
B: old passholder volume 2008/9 at free fare (including 'type 1' new pass holders)
C: prevailing concessionary fare 2005/6
D: old passholder volume and fare at 2005/06 concessionary fare
E: old passholder volume and fare at 2005/6 full fares
F: old and new passholders observed volume 2008/9 at free fares
G: volume and fare at 2008/9 full fare
H: old and new passholder trip volume with shift for abstraction at 2008/9 full fares

I: old and new passholder trip volume with shift for abstraction at 2005/6 concessionary fares

Figure 5: Construction of illustrative single demand curve

In figure 5, reproduced here for convenience, point F is the 2008/9 observed volume. We take away from this the trips made by 'new' passholders. Point B is the result – trips made in 2008/9 by 'old' passholders. We fit a damped proportional elasticity demand curve to link points B and D using a damping factor and spread parameter that are consistent with theory and evidence and check that the implied elasticities at half and full fare for old passholders are consistent with the evidence summarised in paragraph 38 This is then used to extrapolate to full fare, based on the modelled old passholder response. Thus the 'old' passholder curve goes from B to D to E.

The vertical axis of Fig 5 is the fares index, so for the PTEs in 2005/6, the average concessionary fare of 40 pence corresponds to index number 0.36 and the full fare of 112 pence to index number 1.00. In the Shires, a half fare scheme is assumed, i.e. index 0.50. The 2008/9 full fare is index 1.061 based on an assumed real fare uplift of 2% per annum compound from 2005/6.

The upper part of the old passholder demand curve is also the upper section of the piecewise demand curve in Figure 5. Below the prevailing concessionary fare, this curve is drawn to meet the horizontal axis at volume=100, that is the 2008/9 observed concessionary volume at zero fare. This volume obviously includes both 'old' passholders and 'new' passholders.

Formally, it is constructed using a negative exponential demand curve with the same damping factor as the upper section – creating a piecewise demand curve with two sections and a join at prevailing concessionary fare at point D.

We then fit a single, continuous demand curve to pass through the three key points – the zero fare point, the 2005/6 concessionary fare, and the projected point at assumed 2008/9 full fare. This is a damped negative exponential curve which 'envelopes' points G, D and F. At point D, it is necessarily shallower than the upper part of the previous piecewise demand curve and steeper than the lower part of the piecewise demand curve.

We then take account of the trips that would have been made at commercial fares by new passholders (abstraction) through a parallel shift of the demand curve at and above the concessionary fare level – this has a relatively small but not negligible effect on the results. (The graph has been drawn to illustrate the effects and is not necessarily representative of their scale.) Thus the portion ED of the original or piecewise demand curve is shifted out to HI. A new construct using the original damping factor is made from I to F.

Finally, a single continuous demand curve is fitted to pass through the three key points – the zero fare point, the 2005/6 concessionary fare, and the projected point at assumed 2008/9 full fare, having allowed for abstraction from commercial traffic. This is a damped negative exponential curve which 'envelopes' points H, I and F. At point I, it is necessarily shallower than the upper part of the previous piecewise demand curve and steeper than the lower part of the piecewise demand curve.

The line HIF shows the relationship between fare and volume for all those people who have concessionary passes at free fare. Point H is the volume of trips that would be made by all concessionary pass holders if they had to pay the 2008/09 full fare.

This method thus has the following properties with regard to known and/or best estimated data and elasticities:

- It reproduces current observed concessionary demand (indexed to 100 for convenience).
- It reproduces observed concessionary demand (indexed) under half fare (County) or bigger discount (Mets).
- It reproduces demand elasticities for "old" passholders at prevailing concessionary fares in the ranges outlined in paragraph 21 of around -0.23 for the Mets and -0.36 for the Counties.
- It reproduces demand elasticities for "old" passholders at full commercial fare in the expected ranges (as shown in para 36).
- It allows for the potential abstraction from trips at commercial fares by new passholders.

Values of the parameters β and λ have been estimated for the four PTE and seven County scheme areas, and represent working assumptions that could be used in refining the application of the formula. The curve allows the Reimbursement Factor at full fare to be calculated, as shown in Table 1 (reproduced below).

Table 1 Concessionary Reimbursement Model		
	PTEs	Shires
Input Values		
Old passholder trip ratio (2005/6 : 2008/9)	0.753	0.671
Fare Index (Conc Fare/Comm Fare 2005/6)	0.36	0.50
Damping Factor λ	0.8	0.9
New pass holder trip proportion	0.058	0.232
Abstraction Factor	0.3	0.3
Intermediate Outputs		
Point el at 05/06 conc fare for old passholders	-0.23	-0.36
Point el at 05/06 full fare for old pass holders	-0.51	-0.67
Final Output Values		
Elasticity constant (β)	-0.67	-0.84
Whole market damping factor (λ)	0.72	0.64
Whole market el at projected 08/09 full Fare	-0.51	-0.56
Reimbursement Factor at projected 08/09 Full Fare	0.50	0.42

Note that there is no longer a direct link between old passholder elasticity at full fare and the reimbursement rate. Instead, it is the calculated overall point elasticity and the overall λ parameter which determine reimbursement.

The process in Table 1 is to be interpreted as follows. For example, in the top section, for the PTEs, we start with a proportional elasticity model with an assumed damping factor of 0.8 (input assumption); fit a demand curve to the change in trips between those at the concessionary fare in 2005/06 and zero fare in 2008/09 which implies an elasticity at the stated full fare of -0.51 for old passholders (intermediate output to be compared with evidence) ; apply the abstraction ratio (input assumption) ; estimate a new single demand curve to fit the revised price/quantity points (arithmetically yielding proportionality constant -0.67 and damping factor 0.72) and obtain output elasticity of -0.51 and Reimbursement Factor of 50%

<u>The calculations</u>

We now demonstrate the calculation of the Reimbursement Factor calculation based upon a damped form of exponential model of the form $T = k * Exp(\beta F^{\lambda})$ where T = trips at fare F, β is an elasticity constant and λ is a damping factor. This allows the Reimbursement Factor RF, the ratio of trips at the commercial fare F to trips at a zero concessionary fare to be calculated.

We describe the process in words, linking to the spreadsheet; then present the key equations; then a worked example.

1. Start with 100 observed concessionary trips (index) at zero fare (Cell B6 sets this. Can be based in other units if desired. Replicated in cells E35 to J35)

2. Take out trips by passholders who take up the pass for the first time when fares are free or previously used tokens and put the ratio of old passholder free trips to total free trips in Cell B9 (this then creates Cell B35)

   94.2 (Mets: Research Report 5, table 5)

   76.8 (Shires: Research Report 5, table 10)

3. Estimate the trips at the 2005/06 concessionary fare by old passholders. Use Cell C1 to control the Old Passenger ratio of concessionary (fare paid) trips to free trips

   0.753 x 94.2 = 70.9 (Mets)

   0.671 x 76.8 = 51.6 (shires)

4. a) Fit a damped exponential curve to the old passholder data at zero and concessionary fare in 2005/06. λ and b are jointly determined to be consistent with theory and evidence. In practice, one can choose λ so that b falls out - there is <u>one</u> degree of freedom. This generates the data in column B

b) Given b and λ the spreadsheet calculates the elasticity at the full fare in 2005/06. This elasticity should be checked for consistency with the evidence described in paragraph 38.

The full fare elasticity is reported in Cell C2 and in Cell C40. Another test of reasonableness is the elasticity at half fare, reported in Cell C42. These are for old passholders.

c) This is now the old passenger demand curve. Below concessionary fare, it just represents old passholders. But it is the whole demand curve at concessionary fare and above EXCLUDING commercial abstraction.

5. Not strictly necessary because it does not affect anything except the drawing of the graphs, fit a damped exponential curve to the old passholder trips at concessionary fare and volume index 100 using the same λ as in 4.

   This is Column E. We now have a kinked demand curve which represents the whole market excluding commercial abstraction. The kink is at the concessionary fare in 2005/06.

6. Using concessionary volumes at free fare (Cell F35), at old concessionary fare 70.9 (mets) and 51.6 (shires) (Cell F26) and the forecast volumes at 2008/9 full fare (1.061 by assumption of 2% compound real inflation) (Cell F18) to fit a <u>single</u> damped exponential curve to the whole date. There is a unique solution. The intermediate solutions for b and λ are calculated in Cells G7 and G8. These parameters are then used in Column G to generate volume data at a range of fares for this single demand curve. Note that we have not yet allowed for abstraction from commercial fares.

7. Allow that 30% of new passholder trips are abstracted from commercial at old concessionary fare and higher. Enter 0.3 in Cell H9. (Use another figure if there is suitable evidence.)

   → 5.8 x 30% = +1.74 to volumes at fares 0.36 and above (m)

   → 23.2 x 30% = + 6.96 to volumes at fares 0.5 and above (s)

   This immediately affects Cells H18 and H26 and sets the new targets. For comparative purposes, the abstraction increment is added to all the elements of Column G and reported in Column I; this will ultimately enable comparison with the final estimated single demand curve.

8. Fit a <u>new</u> <u>single</u> damped exponential curve to the volumes at free fare (Cell H35), at old concessionary fare (Cell H26) and at 2008/9 full fare (Cell H18). There is a unique solution. The final solutions for b and λ are calculated in Cells J7 and J8. These parameters are then used in Column J to generate volume data at a range of fares for this single demand curve.

9. Since the volume data are indexed to 100, then the reimbursement factor at any prevailing fare (in 2005/6 terms) is simply given by the volume at that fare. So in the Mets, if the current fare is the same in real terms as the 2005/6 fare, then the reimbursement factor associated with a fare

of 1 is 51.2. If, in the shires, the current fare is 10% higher in real terms than the 2005/6 fare, then the reimbursement factor associated with a fare of 1.1 is 41.1

The underlying equations

10. $Q_{old} = F\exp(bp^{\lambda})$ F = old ph trips/total ph trips 2008/9
Choose b, λ to replicate desired elasticity

11. $Q_{old} + new = F\exp(bp^{\lambda})$ for $P \geq$ old conc fare
$= 100\exp(gp^{\lambda})$ for $P <$ old conc fare

12. $Q_{single} = 100\exp(cp^{\delta})$ where c, δ chosen to fit $F\exp(b1.061^{\lambda})$ and $F\exp(b0.5^{\lambda})$ (Shires), $F\exp(b0.36^{\lambda})$ (met)

13. $Q_{single + abstracted} = 100\exp(ap^{\gamma})$ where a, γ chosen to fit $100\exp(cp^{\delta})$ + 30% NPA* at full fare and old concessionary fare

*New passholder abstraction

Reimbursement factor = exp(a) at 2005/6 fare of 1

Given b, λ, there are closed form solutions for c, δ, a, γ

From 10, b = $$\frac{\left[\dfrac{\ln(Q_{old}(at\ conc\ fare))}{F}\right]}{(conc\ fare)^{\lambda}}$$

So choosing λ determines b

From 12 $$100e^{c0.5^{\delta}} = Fe^{c0.5^{\delta}}\ (Shires)$$

$$100e^{c0.36^{\delta}} = Fe^{c0.36^{\delta}}\ (mets)$$

→ $c0.5^{\delta} = \ln(0.01F) + b0.5^{\lambda}$ (shires)

but also $c1.061^{\delta} = \ln(0.01F) + b\,1.061^{\lambda}$ (shires)

(and similar for mets)

→ $\ln c + \delta\ln 0.5 = \ln[\ln 0.01F + b0.5^{\lambda}]$

$\ln c + \delta\ln 1.061 = \ln[\ln 0.01F + b1.061^{\lambda}]$

→ $$\delta = \frac{\ln\left(\dfrac{\ln 0.01F + b1.061^{\lambda}}{\ln 0.01F + b0.5^{\lambda}}\right)}{\ln\dfrac{1.06}{0.5}}$$

$$\rightarrow c = \frac{ln0.01F + b0.5^{\lambda}}{0.5^{\delta}}$$ (replace 0.5 by 0.36 for Mets)

Adding commercial abstraction A trips

$$100e^{a1.061^{\gamma}} = 100e^{c1.061^{\delta}} + A$$

And $100e^{a0.5^{\gamma}} = 100e^{c0.5^{\delta}} + A$ $(shires)$

Or $100e^{a0.36^{\gamma}} = 100e^{c0.36^{\delta}} + A$ $(mets)$

$$\rightarrow \gamma = \frac{\ln\left(\dfrac{[\ln(e]^{c1.061^{\delta}} + 0.01A)}{\ln[(e]^{c0.5^{\delta}} + 0.01A)}\right)}{\left(\dfrac{\ln 1.06}{0.5}\right)(Shires: replace\ 0.5\ by\ 0.36\ for\ Met)}$$

$$\rightarrow a = \frac{[\ln(e]^{c0.5^{\delta}} + 0.01A)}{0.5^{\gamma}}$$ (likewise)

Worked example using worksheet METS

F = 94.2 Try λ = 0.8 → b = $\dfrac{\left(\ln \dfrac{70.9}{94.2}\right)}{0.36^{0.8}} = -0.634$ (Cell B7)

This gives elasticity in 2005/6 at fare index 1 of bλ = -0.51.

If this is acceptable – run with this b,λ

This gives full fare trips at 2008/9 prices (1.061) of 48.0

And conc fare trips at 0.36 of 70.9

Add in abstraction 1.64 trips to fares 0.36 and above to get volumes 72.7 and 49.8

Then $\gamma = \dfrac{\ln \dfrac{ln0.498}{ln0.727}}{\dfrac{\ln 1.061}{0.36}}$ = 0.723 (Cell J8)

a = $\dfrac{ln0.727}{0.36^{\gamma}}$ = -0.669 (Cell J7)

Thus overall demand function allowing for abstracted commercial revenue is

Q = 100exp(-0.669p$^{0.723}$) which yields quasi-full fare elasticity -0.505 (cell J40) at 2008/9 fares and a reimbursement factor of e$^{-0.505/0.723}$ = <u>0.498</u> (Cell J18) at 2008/9 fares.