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| ***passenger transport executive group*****Issues with DfT Guidance and Calculator for Concessionary Travel Reimbursement***Version 5 of May 2014* |  |

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# INTRODUCTION

The Department for Transport (DfT) provides Guidance to English Travel Concession Authorities (TCAs) on how to calculate reimbursement for bus operators to compensate them for carrying free bus passengers under the English National Concessionary Travel Scheme. DfT’s Guidance does not have the force of law, but since it is the basis on which DfT will determine appeals that bus operators may make if they believe a TCA is not reimbursing them properly, it carries substantial weight. DfT also makes available a Calculator spreadsheet which implements the recommendations in the Guidance, and can be used by a TCA to calculate the reimbursement due to an in individual operator from a TCA.

Current Guidance[[1]](#footnote-1) on reimbursement of concessionary travel for older and disabled people was largely devised in 2010, for application from April 2011, and has been marginally revised in subsequent years. The final version of the Guidance published for 2011-12 was subject to a number of iterations, during which some key principles were revised and associated text rewritten[[2]](#footnote-2).

***pteg*** and other interested parties have continued to be involved in dialogue with DfT throughout the evolution of the Guidance to the present day. All parties acknowledge that the subject of concessionary travel reimbursement is very complex and that in combination the large number of assumptions that need to be made lead to significant uncertainties. However, there are a number of issues on which there are differing views, which have substantial reimbursement implications. To date, modifications to the Guidance since November 2010 have been very minor. This may reflect DfT concerns that any significant changes to the Guidance would have a destabilising effect on many existing arrangements between TCAs and bus operators. However, pressure for more wide ranging revisions to the Guidance is likely to grow in the future.

Over the years, ***pteg*** has undertaken technical research in a number of areas, which has often complemented analysis carried out by individual PTEs in the context of revisions or updates of local reimbursement arrangements. The purpose of this paper is to collate this experience into a form that is readily accessible in the future, either for use in dialogue with DfT as and when further revisions to the Guidance are contemplated, or for use by PTEs in local negotiations.

The audience for the paper is primarily technical. Even so, it is quite likely that most readers will have only occasional contact with detailed aspects of reimbursement calculations. Consequently the next section provides an overview of the theoretical rationale for the reimbursement process. Later sections then discuss in detail the three main components of reimbursement, namely the measurement of average fares, estimation of the Reimbursement Factor, and additional costs.

Appendix 1 reproduces the list of issues and concerns that was collated last year, when there were indications that DfT was actively considering significant changes to the Guidance. This paper provides further documentation of each of these issues, as well as a guide to additional evidence or references where available. Appendix 2 lists these external references. Note that the status of the referenced documents varies considerably, from fully published, public domain material to internal notes that may not be circulated without permission.

# OVERVIEW OF CONCESSIONARY TRAVEL REIMBURSEMENT CONCEPTS

The over-arching principle on which reimbursement should be calculated in England[[3]](#footnote-3) is that bus operators, both individually and in aggregate, should be left “no better off and no worse off” financially through the provision of free concessionary travel. This requires concession authorities to identify the difference between the financial positions of the operator with and without the concession, by reference to a counter-factual situation in which no concession is provided.

The established practice is, at least in principle, to calculate reimbursement relative to the observed number of concessionary journeys actually carried by the operator, and some measure of the average fare that would have been charged for those journeys. Adjustments are then made for:

* the likelihood that in the counter-factual, fewer journeys would have been made by concessionary passholders (because some observed concessionary journeys have been generated by the concession);
* there is likely to be some difference between the average fare that is most easily measured, and the average fare that would have been paid by passholders in the absence of the concession
* the likelihood that the operator will incur some additional costs associated with carrying generated concessionary passengers.

These are the three fundamental building blocks on which concessionary travel reimbursement calculations need to be based, which involve connected but quite distinct concepts. In practice, reimbursement payments due to an individual operator for a specific period might be calculated by applying a single combined rate. But in determining the rate, it is essential to keep the different elements separate.

Figure 1 summarises the conceptual calculation flow. Typically, payments for an individual operator will be driven by the number of concessionary journeys carried in a particular period, and the indicator of the commercial fare in that period (e.g. the average cash fare). Reimbursement is calculated from formulae which combine these local variables with other parameters that are relatively fixed.



**Figure 1 Reimbursement Calculation Flow Chart**

The calculation process involves a number of steps.

First, the average fare that would be paid by concessionary passholders in the absence of the concession is calculated (sometimes called the “average fare forgone”). In the DfT Calculator, the calculation is driven by an estimate of the average cash fare paid, which is then reduced via a discount factor intended to reflect the availability of various discount tickets (such as day tickets), and the probability of these tickets being used by passholders.

Second, a demand model (which simulates how passenger volumes vary with changes in fare) is used to determine the proportion of concessionary passenger journeys “generated” by the concession. This is necessary because it is not possible to directly observe the journeys that would have been made in the counterfactual. Instead, observed concessionary journeys are used as a proxy, but with allowance made for generation, i.e. the proportion of concessionary journeys that would not have been made at the commercial fare.

In the DfT Calculator, the measure of generation is the “Reimbursement Factor”, which is the ratio of passenger journeys at the commercial fare, to passenger journeys at the concessionary fare. The demand model parameters reflect assumptions about the sensitivity of demand to fare levels (often summarised as an elasticity); the Reimbursement Factor is a function of these parameters, as well as the average fare forgone.

Third, once the Reimbursement Factor has been calculated, it can be applied to the observed quantity of concessionary journeys to estimate the quantity of non-generated journeys (i.e. the number that would be made in the counter-factual), and the number of generated journeys.

Fourth, since the objective is that the operator should be financially no worse (or better) off, the reimbursement due for revenue forgone is the revenue that would be earned by the operator in the counterfactual. This can be thought of as the hypothesised commercial revenue, which is the product of the non-generated (“commercial”) trips and the average fare forgone. Note that if the concession was not free, then revenue forgone would be the hypothesised commercial revenue. Less any revenue from fares paid directly to the operator by concessionary passengers.

Fifth, since operators will carry additional passengers because of the concession, they are likely to incur some additional operating costs. The DfT Calculator estimates an additional cost rate per generated passenger using various factors that reflect network characteristics, which when multiplied by the number of generated passengers gives reimbursement for additional costs.

Total “no better off, no worse off” reimbursement is then the sum of the reimbursement for revenue forgone, and reimbursement for additional costs.

The DfT Calculator implements this sequence of calculations in an Excel spreadsheet. The user is required to fill designated cells with input values (for example, with the year of calculation, the number of concessionary journeys made, and then the more detailed inputs for the other components), with macros used to shift the focus of calculation between separate worksheets. Although this works adequately as a one-off process for an individual operator, it is cumbersome and inefficient where a TCA must calculate reimbursement for a large number of operators. In practice, therefore, the Calculator spreadsheet tends to be used as a guide to the reimbursement that would be calculated with strict observance of the Guidance, but other mechanisms are used for the practical calculation of payments due to individual operators.

However, the Guidance is clear that in the event of an appeal by an operator, DfT will use its Calculator to inform a decision on the correct level of “no better, no worse off” reimbursement. Consequently, there is a need to ensure that reimbursement arrangements lead to operator payments that are consistent with those that would emerge from the Calculator, or that there is a clear rationale for why results may be different.

# AVERAGE FARE ISSUES

One of the three key components of reimbursement calculations is the mechanism for estimating the average fare forgone - that is, the average fare revenue per passenger journey that operators would receive from passholders in the counter-factual.

The fares charged by an operator to different groups of passengers making different sorts of journeys vary widely, and may reflect a range of ticket types that are on offer. Across an operator as a whole, the overall average fare will be subject to small variations on a day-to-day basis, reflecting fluctuations in the passenger mix, and changes in fare levels determined by the operator on a commercial basis. Operator reimbursement depends upon an estimate of the average fare that concessionary passengers would have paid for their journeys in the absence of the concession, and therefore needs to reflect both the variations in fares paid by individual passengers, and the extent to which concessionary passengers (who actually travel for free) would take up each of the different ticket types on offer.

Standard practice is to measure the general level of fares, as is likely to fluctuate over time, using a relatively easily calculated quantum such as the average cash fare paid per journey by commercial passengers. This is sometimes called the Reference Fare. For some of the PTEs, the Reference Fare is calculated from survey data that measures concessionary passenger journey trip lengths and compares them to adult cash fare scales. For other TCAs, it is often estimated from auditable returns provided by an operator that can be traced back to individual passenger ticket transactions. The Reference Fares is usually based on adult cash fares (i.e. adult single “walk-on” fares, potentially returns fares etc), and so “average cash fare” is often used as short-hand for the concept of the Reference Fare. The Guidance says very little about the Reference Fare, a weakness which is discussed in more detail below.

The average fare forgone is then estimated by applying a Discount Factor to the Reference Fare. The Discount Factor is intended to reflect the likelihood that in the absence of the concession, passholders would make use of a wider range of ticket types than those reflected in the Reference Fare, e.g. would purchase daily or weekly discount tickets as well as cash fares. At present, the Guidance does not recognise that passholders would use anything other than cash fares, day tickets or weekly tickets in the counter-factual; as discussed below this represents a concern as smartcard-equipped buses provide scope for more variants in ticket types.

The Guidance identifies two alternative methods for estimating the Discount Factor. DfT’s recommended approach is to use what DfT call the “Discount Factor method”. The alternative offered is labelled as the “Basket of Fares method”. Either method results in a discount factor that, within the DfT Calculator, is applied to the average cash fare per journey to produce the average fare forgone.

Although the Guidance does not make this clear, in effect with either method the discount factor is calculated from a weighted average fare. The difference between the two methods is that:

* with the “Discount Factor method”, the weights and average fare per journey are derived through an automatic process within the Calculator by reference to a look-up table, and are not provided by the user.
* With the “Basket of Fares method”, the weights and average fare per journey needed to populate the weighted average fare calculation must be user-specified;

To avoid ambiguity, when we refer to “the Discount Factor method” we mean the process of deriving an average fare forgone using a look-up table; otherwise, the term “discount factor” is used to refer to the outcome of either of these two methods, which is a measure of the extent to which the Reference Fare (e.g. the average cash fare) should be reduced to reflect the likely use of discount tickets in the counter-factual.

## Nature of the look-up table

The look-up table summarises the frequency with which concessionary passholders have been observed to make trips every day and every week. . It was built from concessionary journeys recorded using smartcards collated by the “NoWcard” group of authorities, and is often referred to as “the NoWcard look-up table”. For a large number of combinations of relative prices of cash fares, day tickets and weekly tickets, the look-up table identifies the number of occasions on which sufficient journeys were made per week for it to be cheaper for passholders to make their observed journeys with a weekly ticket, and likewise for journeys per day and daily tickets

A fragment of the look-up table built into the Calculator is in Figure 2, which shows the look-up table entries for daily ticket price multiples of 3 and 4 (in other words, situations in which the daily price is 3 or 4 times the average cash price per journey), and weekly price multiples of 11, 12 and 13.



**Figure 2 Fragment of Average Fares Look-up Table**

Each entry (i.e. block of cells for a given pair of day and weekly price ratios) shows how the observed NoWcard concessionary passholder journeys would be assigned between weekly tickets, daily tickets and cash fare journeys. For example, for a weekly price ratio of 11 and a daily ticket price ratio of 3, the look-up table reports that

* There were 10,517 weeks (within the total captured by the NoWcard smartcard data) in which 11 or more concessionary journeys were made, and in these weeks 162,809 journeys were made;
* Of the remaining journeys, 80,177 journeys were made on days in which 3 or more journeys were made. There were 80,177 such days.
* 348,077 journeys were made during weeks in which fewer than 11 journeys were made, and on days in which fewer than 3 journeys were made.

Each block of cells reports on how the same total number of journeys (591,063 journeys in the case of the NoWcard data) would be assigned between cash, day and weekly journeys on the basis that, for example, if a weekly ticket costs 11 times the cash fare, then in the counter-factual, concessionary passholders who make 11 or more journeys per week will buy a weekly ticket. The result is that for each combination of price ratios, the look-up table allows us to identify the proportion of journeys that would be made using each ticket type, and the average number of journeys made per ticket purchased. For example, if the weekly ticket price is, say, £15 and this represents eleven times the average cash fare per journey, the look-up table allows us to calculate that the average weekly ticket price per journey is £15 \* 10,517/162,809 = £0.969.

The journey proportions and average price per journey by each ticket type are the key variables needed to carry out a weighted average fare calculation.

The advantage of the look-up table approach is that it reduces the need for externally derived assumptions about the relative usage of different ticket types. Without it, the journey proportions and average prices per journey might not be known with any confidence for day and weekly tickets. It allows TCAs to derive an average fare forgone using only information from operators on ticket prices, which in principle can be readily audited.

However, the likelihood that this approach will lead to “no better, no worse off” reimbursement depends on the extent to which the default look-up table built into the DfT Calculator is fully representative of individual TCA areas. The default look-up table was built from 5 weeks of data collected in 2009 on the concessionary journeys made by passholders living in four districts in Lancashire, and the reliability of the approach depends upon the journey frequencies of concessionary passholders in the TCA areas being similar to those from which the default look-up table have been constructed.

## Building and use of alternative look-up tables.

Most TCAs do not have the means of constructing look-up tables from their own areas, but PTEs are increasingly able to do so.

Look-up tables need to be built from data on ENCTS concessionary journeys recorded by smartcard equipment. There are other ways in which partial information of journeys frequencies can be calculated (e.g. from surveys) but none have the potential for completeness[[4]](#footnote-4) that smartcard data represents. Even smartcard data may not be sufficiently complete to give reliable look-up table results if smartcard implementation amongst bus operators is partial. Incomplete capture of the journeys made by passholders will lead to understated journey frequencies and the possibility of under-estimated discount factors.

The pace at which bus operators have implemented smartcard-based recording of ENCTS has been slower than expected, and although a number of PTEs have built their own look-up tables, at present the most reliable alternative to the default has been constructed by Centro[[5]](#footnote-5). This provides nearly 95% smartcard coverage of concessionary journeys in the West Midlands, very similar to the level of completeness offered by the NoWcard data.

The Centro data demonstrates that concessionary journeys are made much more frequently in the West Midlands than in the areas from which the default look-up table was built. Table 1 summaries the number of journeys that populate the NoWcard and West Midlands look-up tables, the number of passholder-weeks in which at least one journey was made, and the average journeys per week[[6]](#footnote-6) that results.

|  |  |  |
| --- | --- | --- |
|  | Default NoWcard data (2009) | West Midlands data (2013) |
| Total number of journeys | 591,063 | 32,218,934 |
| Number of passholder weeks with at least one journey recorded | 123,557 | 4,468,929 |
| Average number of journeys per non-zero week | 4.784 | 7.210 |
| **Table 1 Comparison of NoWcard and West Midlands Journey Frequencies** |

The journey rate per non-zero journey week in the West Midlands is about 50% higher than in the NoWcard area, implying that there will be more occasions on which passengers are making sufficient journeys to justify the purchase of day and weekly discount tickets.

This is confirmed in Table 2, which compares the average fare forgone and discount factors calculated using the West Midlands and NoWcard look-up tables. The illustration uses 2013 ticket prices for some example PTE operators.

|  |  |  |  |
| --- | --- | --- | --- |
| Illustration of Fares and Discount Factors | Operator A | Operator B | Operator C |
| Average cash price per journey | £1.60 | £2.04 | £1.97 |
| Average price per day ticket | £5.00 | £4.50 | £4.09 |
| Average price per weekly ticket | £17.00 | £15.77 | £12.92 |
| Average fare forgone (NoWcard look-up table) | £1.54 | £1.84 | £1.72 |
| Discount factor from NoWcard look-up | 3.7% | 9.8% | 12.6% |
| Average fare forgone (Centro look-up table) | £1.42 | £1.61 | £1.47 |
| Discount factor from Centro look-up table | 11.4% | 20.9% | 25.6% |
| *Error if default look-up table used* | *8.5%* | *14.3%* | *17.0%* |
| **Table 2 Impact of alternative look-up tables on Discount Factors** |

Looking at the values for Operator A, the average fare forgone that would be calculated is £1.54 with the default look-up table (a discount factor of 3.7% relative to the average cash fare). With the look-up table derived from West Midlands data, the average fare forgone would be £1.42 – an 11.4% discount factor. This implies that if the area in question is more similar to the West Midlands than the Lancashire districts in terms of journey frequencies, then the average fare forgone might be overestimated by 8.5%. This would be translated directly into a significant over-payment of reimbursement for revenue forgone. If bus operator ticket prices offer more attractive day and weekly fares (e.g. such as Operator C), the error would be much greater at 17.0%.

The use of an inappropriate look-up table could therefore significantly bias estimates of the average fare forgone. Since this is often the most significant component of the overall reimbursement calculation, the potential for non-compliance with the “no better off, no worse off” objective is very large, if look up tables appropriate to the local area are not used.

Ideally, local look-up tables should be built for any given area, but this is a remote possibility for most TCAs, and currently is difficult to achieve even in all PTE areas. The next best option is therefore to demonstrate that the look up table selected for application in a given areas is similar to that of the area from which the table was built. The Guidance already acknowledges[[7]](#footnote-7) that large urban areas may be different to those from which the default look-up tables were derived. It is possible to demonstrate that on the basis of a variety of socio-economic characteristics, the PTEs as a whole have more in common with each other than they do with the 4 Lancashire districts. However, it is likely that systematic differences between area types still apply, and it would be better if DfT promoted a mechanism through which look up tables for an “application” area could be better matched to those of a “reference” area.

Such a mechanism was developed for DfT and described in an unpublished research report by MVA Consultancy[[8]](#footnote-8), finalised in May 2012. This work also rebuilt new look-up tables from NoWcard data, using a larger number of districts encompassing a wider spread of area types, and for a whole year as opposed to just five weeks. DfT has not, as yet, incorporated any of the results from this work into the Guidance or the DfT Calculator, leaving authorities with a choice of using either the entirety of the default look-up table, or a look-up table from another area. But no mechanism is available for systematically representing an in-between state. However, ***pteg*** could make use of the same concepts to those set out in MVA’s work for DfT to allow a PTE to demonstrate that it had reflected its own characteristics in the choice of look-up table it had adopted. This would protect such a PTE from the criticism that it was not sufficiently similar to, for example, the West Midlands to justify using a look-up table built by Centro, as opposed to the NoWcard default[[9]](#footnote-9).

Apart from debate about the similarity of one TCA area as a whole (e.g. Greater Manchester) to another (e.g. West Midlands), individual bus operators have also been known to argue that their own operating territory is significantly different to the generality of a PTE area to justify using the NoWcard table for its services. As with many aspects of reimbursement, in principle there is a theoretical case for better matching various inputs into the reimbursement calculator to the characteristics of individual areas, and potentially individual operator catchments, and this argument might apply to look-up tables. But at present with the choice restricted to only a crude “either NoWcard/or ANO area” it is highly unlikely that the catchment of an individual operator within a PTE area would be sufficiently different to the rest of the PTE area to justify use of a wholly different look-up table.

## DfT Calculator Implementation of the Discount Factor method

There appear to be a number of errors in precisely how calculations are carried out regarding the application of “degeneration”[[10]](#footnote-10), and how the final discount factor is calculated. These are difficult to appreciate without a detailed explanation of how the methodology is intended to work, which is set out in a separate file note[[11]](#footnote-11). However, the key observations are as follows:

* Calculation of “Degenerated” price ratios – there is no apparent rationale for the way in which Reimbursement Factors are currently applied. The arithmetic in the DfT Calculator will underestimate the degenerated price ratios, leading to over-estimates of discount factors.
* The method for applying degeneration to the volume of cash journeys appears arbitrary, and equally valid calculations would have the impact of significantly increasing the proportion of journeys assigned to discount tickets and hence increasing discount factors overall.
* The calculation of the “final” discount factor in cell AG18 does not seem consistent with the principles that should be used for estimating the weighted average fare. Correct calculation would lead to significant increases in the estimated discount factor if all other factors remained the same.

Overall, we believe that the net effect is that the Calculator as it currently stands will significantly and systematically underestimate the discount factors that should be calculated for a given set of input ticket prices, and consequently will lead to underestimates of reimbursement for revenue forgone.

There is some evidence that supports this conclusion through comparisons of the results of “Basket of Fares” type calculations and the equivalent ”Discount Factor” calculations[[12]](#footnote-12). In general, authorities are unlikely to have the data from which to construct a robust basket of fares calculation. Even in PTE areas where comprehensive survey data may be available on passenger journeys, the PTE may not have revenue visibility on the full range of commercial ticket products offered by the operator. However, data is available in at least two PTE areas, which either on the basis of entirely their own data, or through a combination of their own survey data, and revenue data supplied by some of their major operators, enables a basket of fares calculation to be populated without relying on too many assumptions.

The key assumption underlying basket-of-fares calculations is that concessionary passholder ticket-buying in the counter-factual will be similar to that of commercial adult passengers[[13]](#footnote-13), with exceptions such as the likelihood that passholders will make little or no use of period tickets for longer than a week. On this basis, where the most complete information is available, discount factors would seem to be justified that are at least double those estimated by the DfT Calculator. This evidence supports our view that the current implementation of the Discount Factor method in the DfT calculator will systematically underestimate discount factors, and will leave operators better off than in the counter-factual, all other things being equal.

## The average cash fare and Reference Fare

It was noted above that in calculating reimbursement, the average fare forgone is estimated by applying the Discount Factor to a Reference Fare. Implicitly, the Guidance assumes that the Reference fare is identical to the average cash fare input into the Discount Factor calculation (i.e. the value used to estimate day and week price ratios and hence draw appropriate discount factor values from the look-up table). Most TCAs will rely upon operator estimates of the average cash fare paid by adult commercial passengers, which can be relatively easily reported by operators, and the same measure will be used for both roles.

PTE reimbursement methods often use continuous survey data to estimate what is frequently referred to as an “equivalent cash fare”, derived from the journey length distribution of concessionary passengers applied to a cash fare scale. PTE data[[14]](#footnote-14) can often demonstrate that the journeys length distributions of different groups of passengers will not be identical, and this can lead to significant variations in the average equivalent cash fare that might be calculated. In particular:

* the average equivalent cash fare of concessionary passengers is often (but not always) higher than the average cash fare paid by commercial passengers;
* commercial pricing strategies may lead to the journey lengths of commercial cash passengers being significantly different to that of users of daily and weekly tickets.

At present there is no facility within the DfT Calculator to distinguish between, on one hand, the measure of average cash fare used to estimate the average fare forgone, and on the other hand, the measure of the cash fare that is used to calculate period by period reimbursement. There is a concern is that the measure of the cash fare that is used for monitoring period by period fare levels, such as the adult equivalent cash fare of concessionary passengers, may not be the most appropriate input into the calculation of the average fare forgone.

An important issue here is that the average fare forgone needs to accurately reflect the ticket price options that would be offered to concessionary passholders in the counter-factual. There are arguments that could be had about the commercial offer that operators would make to passholders in the absence of the concession, but that is not the issue here. The DfT methodology in effect assumes that best estimate of the day and ticket prices that would be offered to passholders in the counter-factual are those observed to be offered to commercial passengers. However, the question then arises as to the best estimate of the cash fare, as used to determine the price ratios which allow the discount factor to be identified.

Established practice in some PTEs is to measure the cash fare using the average equivalent concessionary fare (in other words, the average cash fare that would be paid by concessionary passholders to make their recorded concessionary journeys, if each journey was “valued” at the cash fare). But as noted, this will often reflect a different average trip length to that of commercial cash passengers: either because the former reflects changed journey lengths influenced by free travel, or because the commercial fare offer favours shorter (or longer) cash journeys lengths relative to the pricing of day or weekly tickets. In either case, it is more likely that the average cash fare paid by commercial (cash) passengers will better reflect the counter-factual cash fare that would be paid by concessionary passengers, rather than the average equivalent concessionary fare.

These considerations will influence the accuracy or otherwise of the average fare forgone calculated by either the “Discount Factor method” or the “Basket of Fares” method. But a second issue is then consistency between the discount factor and the measure of the average cash fare used to calculate the average fare forgone on a period by period basis. If the discount factor is calculated on one basis (i.e. the average cash fare paid by commercial passengers) but the average fare forgone is calculated by applying the discount factor to a different measure (such as the equivalent concessionary cash fare), then reimbursement for revenue forgone will be in error[[15]](#footnote-15).

At present, the DfT Calculator ensures consistency between the average cash fare used for calculating the discount factor, and the calculation of the average fare forgone, because it does not recognise that different measures could be used for the two distinct roles. It would be desirable for the DfT Calculator to be adapted to allow PTEs to calculate a discount factor based on the average cash fare paid by commercial cash passengers (to secure a more accurate estimate of the average fare forgone), and at the same time allow for a different on-going measure of the commercial fare such as the average equivalent cash fare, which is a well-established part of current procedures in some PTEs.

## Need to adapt methods to wider range of commercial ticket types

The “Discount factor method” currently confines estimates of the discount factor to consideration of three generic ticket types, namely cash fares, day tickets and weekly tickets. When devised, longer-period tickets were not included for a combination of pragmatic reasons (to avoid over-complicating the methodology) , and the judgement that few concessionary passholders were likely to make significant use of tickets that were for longer periods than a week. The introduction of smartcard ticket equipment is facilitating the development of “smart” products that do not directly align to the three generic ticket types, for example products that cap expenditure and effectively convert cash fares into day or weekly ticket products if the cardholder makes more than a certain number of journeys. Excluding these from consideration will increasingly lead to the discount method not fully reflecting the commercial choices that passholders would have in the counter-factual, especially as smart products replace the “conventional” day and weekly tickets on which the discount factor method is focussed.

Investigation is needed to identify the nature and potential significance of ticket products that do not match the generic ticket types currently allowed for in the Calculator. Also, smartcard data is also beginning to reveal that a small minority of passholders make very frequent and regular journeys, which potentially throws doubt on underlying assumptions about usage of longer period season tickets in the counter-factual. Should ticket types other than cash fares, daily and weekly tickets prove to be significant in passengers’ choice set of tickets, then the current methodology would need to be enhanced to ensure that it continues to reflect the main choices that passholders would have in the counter-factual.

It should also be recognised that in many areas, particularly for the PTEs, the availability of multi-operator and multi-mode tickets further complicates passengers’ ticket choice. Explicit modelling of how passengers select between the wider range of options available is likely to be significantly more complex than the more pragmatic methods currently employed[[16]](#footnote-16).

It is not clear to what extent ignoring the existence of the wider array of ticket products would lead to a bias in estimated discount factors in one direction or another. To date, the simplifications employed in the DfT Calculator, and pragmatic PTE judgements on how to translate local data into appropriate inputs to the Calculator, have not in themselves been the source of major conflict with operators. However, this situation may change, as pressures on finance increase, and the existence of a wider range of ticket types than is acknowledged by the Guidance becomes more difficult to avoid.

# REIMBURSEMENT FACTOR ISSUES

# The Single Demand Curve

As described in Section 2, the purpose of the Reimbursement Factor (RF) is to estimate the proportion of observed concessionary trips which would have been made in the absence of the concession. Given that it is not possible to directly observe the counterfactual, the quantity of journeys that would have been made in the absence of the concession is estimated by applying the Reimbursement Factor to the observed quantity of concessionary journeys made with free fares.

Prior to the introduction of the DfT Guidance that came into effect in 2010, the RF was most frequent source of conflict about reimbursement between Travel Concession Authorities and bus operators. This was consequently a key area for ITS research, and led to results in two areas that were previously much debated:

* the mathematical formula(e) which should be used to represent the relationship between bus fares and concessionary passenger demand: ITS concluded that Reimbursement Factors should be calculated with reference to a mathematical expression which was labelled a “Single Demand Curve”, the shape and sensitivity of which is determined by a pair of parameters;
* the most appropriate parameters to quantify this relationship, often referred to as fare elasticities: ITS established two alternative sets of parameters, one for PTE areas, and the other for non-PTE areas.

The Single Demand Curve (SDC) is a mathematical formula which relates the demand for concessionary travel to the fare that concessionary passholders might pay. An expression can be derived that allows the ratio of demand at a given commercial fare (i.e. the Average Fare Forgone) and at the zero concessionary fare to be calculated. Arithmetically, this is identical to the Reimbursement Factor, which therefore enables the volume of journeys made by passholders in the counter-factual to be estimated.

For a given Average Fare Forgone F and a zero concessionary fare, the appropriate Reimbursement Factor is calculated using the formula

RF = Exp(βFλ)/ Exp(0) = Exp(βFλ)/1 = Exp (βFλ)

as set out in paragraph C.22 of Annex C (Economic Principles) of the Guidance.

The shape and slope (which determine the point elasticity) of the SDC is controlled by the two parameters, λ and β, established by ITS from analysis of reference data sets with different values for PTE and non-PTE areas. In the case of the SDC for PTEs, the reference data draws on time series data on concessionary journeys made in 2005-6 to 2008-9 in the four PTEs which did not have a zero concessionary fare in 2005-6. The parameters therefore attempt to capture the observed impact of the introduction of free travel on concessionary demand.

Although there inevitably remain areas of uncertainty, by-and-large ITS conclusions on the shape of the demand curve and parameter values have been accepted by the practitioner community. However, there is concern that the way in which DfT recommend that these concepts are applied is inconsistent with fundamental principles of “no better off, no worse off” reimbursement, as well as creating much scope for debate about the practical implementation of the recommended method.

## Reimbursement Factors in the Guidance

Whereas the formula above can easily be shown to estimate the difference in concessionary demand between the fare that passholders would pay in the counter-factual, and demand with a zero fare, the Guidance states (paragraph 6.19) that “the appropriate reimbursement factor must be calculated based on the change in local fares between 2005/6 and the current reimbursement period”. No rationale is provided for this statement, either in the Guidance main text or in the discussion of economic principles. What is not stated is that if local fares have not changed in real terms since 2005/6, the Reimbursement Factor that is calculated is determined by an estimate of the average fare in PTE or non-PTE areas in 2005/6, irrespective of current or historic fare levels in the area for which reimbursement is being calculated. Thus the Guidance in effect standardises reimbursement factors for all operators in PTE areas and non-PTE areas respectively, but with variation between operators reflecting only the change in the fare charged by each individual operator between 2005/6 and the present.

The average 2005/6 full fares assumed in PTE and non-PTE areas are not quoted explicitly nor fully defined, but it is possible to identify them since they are embedded in some of the formulae within the DfT Calculator spreadsheet. The values used by DfT are £1.12 for PTE areas and £1.20 for non-PTE areas. The accuracy of these values is not known, and their provenance and precise definition is uncertain.

The DfT implementation of the Single Demand Curve therefore calculates the Reimbursement Factor without reference to the absolute level of the current fare, and the only local factor that is taken into account is the change in fare from 2005/6 to the reimbursement year e.g. 2011/12. Thus the same reimbursement factor (i.e. assumed level of generation) would be calculated for different operators, irrespective of the fares actually charged by them in the reimbursement period, provided that the change in the fare from 2005-6 in real terms is identical. And operators charging identical fares in the reimbursement year will be reimbursed by differing amounts, depending upon how their fares have changed since 2005-6. This is regarded as potentially being in breach of the 1986 Regulations that individual operators should be financially no better and no worse off. In our view, two operators who charge identical fares and for whom all other characteristics are identical should be reimbursed on the basis of identical Reimbursement Factors.

The extent of the potential error is illustrated in Table 3 below. This shows data for four operators, each carrying 1,000 concessionary passengers and each charging an identical average fare forgone (i.e. after discount) in 2011-12 of £1.50.

 Reimbursement Factors and estimated revenue foregone are shown for fares which have changed in nominal (current price) terms by 50%, 0% and -25%. The change in Operator D is identical to the change in the price index from 2005-6 to 2011-12, in other words represents a zero change in real terms. The calculated Reimbursement factor for Operator D is therefore the “default” value specified in Table 6.1 of the final Guidance. The correct value for the Reimbursement Factor can be calculated directly from the SDC parameters as set out in the ITS recommendations. For a commercial fare of £1.50 in 2011/12, it would be 48%. In no case does the DfT calculator reproduce this figure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Operator A** | **Operator B** | **Operator C** | **Operator D** |
| 2011-12 average fare forgone | £1.50 | £1.50 | £1.50 | £1.27 |
| 2005-6 average fare forgone | £1.00 | £1.50 | £2.00 | £1.50 |
| Change in nominal fares | +50% | 0% | -25% | 17.7% |
| Reimbursement Factor from DfT Calculator | 45.1% | 55.2% | 61.7% | 51.24% |
| Non-generated concessionary trips | 451 | 552 | 617 | 512 |
| **2011-12 Reimbursement for revenue forgone – DfT method** | **£676** | **£828** | **£925** | **£768** |
| Reimbursement Factor calculated direct from SDC[[17]](#footnote-17) | 48.0% | 48.0% | 48.0% | 48% |
| **2011-12 Reimbursement for revenue forgone – using SDC** | **£720** | **£720** | **£720** | **£720** |
| Under- or over-reimbursement | -£44 | £108 | £205 | £48 |
| **Table 3 Illustration of Impacts of DfT Implementation of Single Demand Curve concepts** |

In our view, if operators A, B and C are operating in identical conditions, and charging identical fares, the level of reimbursement that each should receive should be identical. As it is, DfT’s recommended calculation of reimbursement will lead to operator A being under-reimbursed for revenue forgone by 6%, and operator C being over-reimbursed by 28%. Irrespective of the correctness or otherwise of the absolute level of reimbursement, this clearly has the potential for creating significant distortions in the local bus market, with significant windfall gains or losses.

The only situation in which the DfT calculator will accurately estimate revenue forgone on the basis recommended by ITS is when the 2005-6 fare of the individual operator is exactly equal to the average fare (in either a PTE or a non-PTE area) assumed by DfT.

These characteristics are seriously at odds with the underlying assumption of reimbursement calculations that demand varies with the operator’s fare level. It is very difficult to see how this can be reconciled with the TCA objective (as specified by Regulation 4 of TCSR 1986) that operators should be reimbursed so that they are individually financially no better off and no worse off.

## Practical Issues

Quite apart from these issues of principle, the requirement to estimate a change of fares since 2005/6 also raises many practical problems and creates substantial and unnecessary scope for TCA-operator conflict. TCAs seeking to apply the Guidance in, for example 2014-15, need to be able to make consistent, like-for-like comparisons between fares that are nine years apart.

The Guidance recognises that satisfactory estimates of the change in fares from 2005/6 for individual operators may not be readily available, and suggests as alternatives either TCA-wide estimates (in other words, estimates averaged in some way over all operators in the TCA), or alternatively using the National Bus Fares Index which DfT publishes. But the preferred option is to use data that enables the 2005/6 fare charged by an individual operator to be compared with that charged in the reimbursement period. Doing so is particularly difficult and raises a number of questions.

What average fare? The Guidance says that TCAs can estimate “the fare that concessionary passengers would have paid in the absence of a concessionary fare scheme in 2005/6”, in other words the average fare forgone. But it also acknowledges that the methodology for estimating the average fare forgone in 2005/6 may not be the same as in the current period – indeed, this is highly likely since the current recommended method was only made available in 2010. Many TCAs would not have made allowance for discount factors in 2005/6, whereas they will do so if they follow current recommendations. If, with hindsight, the historic average fare forgone should have made more allowance for discount fares than it did, should the comparison be with the 2005/6 value after making a retrospective adjustment? Whatever approach is adopted is likely to provide an unsatisfactory basis for comparisons between 2005/6 and the present.

How to accommodate changes in individual operator service patterns? The likelihood of significant changes in service patterns since 2005/6 was strong even in 2010, and will be a much more common problem today. Second best approaches such as references to TCA-wide or national data seem unavoidable where radical changes have taken place, such as substantial expansion or contraction of services. But reference to these external data sources will inevitably increase the likelihood that the estimate of the reimbursement factor is not appropriate for the individual operator and the fares it currently charges.

What to measure? As is evident from the discussion of the estimation of the average fare forgone, there are a number of ways in which an average fare can be calculated, even if the potential use of discounted fares is ignored. For PTEs, the most readily available data on fares will often relate to the cash fare scale, which might have been supplied by operators as a standard fare scale, or in the form of fare tables. In some instances, an effective operator average fare scale can be constructed from survey data. In conjunction with the survey data, this information then provides the potential for estimating the average cash fare that would have been paid by different groups of passengers. But there is a large range of possible groups for which an equally plausible calculation could be carried out, including:

* actual commercial cash paying passengers
* all commercial passengers, irrespective of the type of ticket actually bought
* concessionary passengers.

Each of these may have different journey length distributions[[18]](#footnote-18) which will lead to varied estimates of the average fare. And since the objective is to measure the average fare at two different points in time, the question then arises as to whether the average fare is calculated relative to the trip length distribution of the selected group of passengers in 2005/6, or the current period, or use different trip length distributions in 2005/6 and the current period. There are therefore many different combinations of passenger group, fare scale and trip length distribution, representing alternative average fare definitions, for each of which there may be a plausible justification.

In practice, for most TCAs, choices will be severely limited by data availability, and PTEs may be unusual in having more options than most. However, some degree of arbitrary choice between these alternatives seems inevitable, and such is the sensitivity of reimbursement outcomes to variations in input values that disputes about the best method to use are difficult to avoid. This is particularly frustrating since the need to estimate the change in fare arises only because of the way in which DfT has chosen to implement the ITS recommendations on Reimbursement Factor calculation. As discussed above, in our view this is misconceived, and itself gives rise to a wholly avoidable departure from “no better off, no worse off” principles.

# ADDITIONAL COSTS

Additional costs arise from the likelihood that some operating costs will increase as a result of an operator having to carry additional passenger journeys which have been generated by the concessionary fare. Other additional costs may also be incurred that are directly attributable to the operator participating in the scheme. Reimbursement for additional costs “necessarily incurred” in providing the concession is intended to ensure that the operator is no better off and no worse off as a consequence of the concession.

 The DfT Calculator provides a standard methodology for calculating different types of additional costs:

* Marginal operating costs. These are costs such as additional fuel, tyre wear and insurance that are likely to be closely related to the number of passengers carried. In the DfT calculator, it is calculated through a simple formula that relates a rate per generated passenger to journey length, although the result is relatively insensitive to this input value
* Marginal capacity costs. These are costs associated with the provision of additional capacity (i.e. extra services and enhanced frequencies) needed to accommodate generated passengers. The Calculator estimates a cost rate per generated passenger, calculated through a complex formula which requires a large number of input variables. It is highly sensitive to these input values.
* Scheme administration costs – the Calculator recognises that a TCA may wish to make payments that reflect administrative costs (for example, if it requires data to be provided in a specific form), but does not seek to calculate them.
* Peak vehicle requirements – the Guidance states that DfT expects that additional peak vehicle requirements [arising from the provision of the concession] will be exceptional, and that operators will have to demonstrate that exceptional or unusual circumstances are relevant. It discusses some aspects of how PVR costs might be calculated, but does not provided a detailed methodology. The Calculator provides for the user to enter a PVR cost (in total) but assumes this will be calculated off-line, independently of the Calculator spreadsheet itself.

Of these elements, there is little to be said about scheme administration costs.

With regard to Marginal operating costs, the principle that some costs, largely “consumables” will be directly affected by additional concessionary journeys is now widely accepted. The formula derived by ITS and included in the Calculator consists of a fixed element and a variable element, determined by the average journey length, which together lead to an average marginal operating cost per generated passenger. With the cost parameters calculated by ITS, the fixed component is much the biggest, and the influence of the average journey length is relatively modest. The average journey length should be that of concessionary passengers, although many TCAs may not be able to distinguish the average journey length of concessionary passengers from that of other passengers.

Determining additional peak vehicle requirements arising from the need to accommodate generated concessionary passengers is potentially even more difficult that determining marginal capacity costs. However, to date these have not featured significantly in detailed local negotiations between bus operators and PTEs of which we are aware, and at present there is little practical experience to provide a basis for observations.

Most debate with both operators and DfT has been on the subject of marginal capacity costs.

# Marginal capacity costs

These are “the costs to a bus operator of carrying additional passengers and allowing the capacity of bus services to increase, by using the existing bus fleet more intensively … through increased frequency”. Reimbursement should be net of the additional revenue generated from commercial [passenger] journeys that arise from increased frequency. They are additional to both marginal operating costs, and to peak vehicle costs.

The Guidance states that “there is a presumption that marginal capacity costs could potentially apply to all routes within a network”, and suggests that they can be calculated either using the DfT Calculator spreadsheet, or by other methods such as counterfactual or hypothetical network models where available. Although there is some discussion of the latter options, the main emphasis in the Guidance is on the DfT MCC Model.

The MCC Model was developed by ITS in its 2009-10 research for DfT and is described at length in the Guidance. However, the logic is opaque, and for reasons that are unclear lead to counter-intuitive results with regard to the impact of the input average occupancy value.

If all other input values are kept constant, lower levels of average occupancy (which imply a higher level of unused capacity) leads to higher estimated values of marginal capacity costs. For example, if input values are set to default DfT recommended values for PTE areas, including DfT’s default value of average occupancy of 10.00, the net cost rate is calculated to be 11.6 pence per generated passenger. If average occupancy is reduced to 9, then the calculated cost rate increases to 16.7 pence per generated passenger. In other words, with 10% fewer passengers on board each bus, on average, the calculated cost of providing additional capacity to accommodate generated concessionary passengers increases by over 40%.

Intuitively, lower occupancy, providing more scope for generated passengers to be accommodated without requiring additional capacity, should be expected to lead to lower levels of marginal capacity cost. But with DfT’s MCC model, the reverse is the case. We regard this as a serious and fundamental weakness in the MCC model.

Unfortunately the flow of calculations within DfT’s spreadsheet is circuitous and over-complicated, and includes a number of variables which have no impact on the output results. For example, users are required to provide the “average route length”, but its value does not affect the results of calculations and its introduction into the arithmetic is redundant and unnecessarily adds to the complexity. Unfortunately, the way in which spreadsheet formulae are constructed, with selections between default and local values imbedded in multiple “IF” statements within individual cell formulae, also makes the logic of formulae opaque and difficult to understand. It is possible to devise an equivalent but much simpler calculation flow that delivers the same logic but much more clearly.

# Sensitivity of results to variation in input values

Apart from the counter-intuitive impact of the occupancy variable, the scale of the impact reflects another troubling aspect of the Marginal Capacity Cost calculator, namely that results can be greatly sensitive to the precise values adopted. This is illustrated in Table 4, which shows the change in overall additional cost per generated passenger, and marginal capacity cost, when individual input values are reduced by 10%. These are all relative to DfT default values for PTE areas.



**Table 4 Sensitivity of output cost rates to changes in input local values**

Of these inputs, concessionary journey length has only a modest impact, and route length none at all. However, a 10% variation in any of the others will, in isolation, lead to proportionately much greater change in the calculated cost rates.

In most areas, data will not be readily available to enable either TCAs or bus operators to accurately estimate many of these values, thus increasing reliance on DfT’s default values. The critical weakness in most areas will be lack of information on journey length, which is strongly related to bus occupancy. PTEs are better equipped than other TCAs with access to data, and some are able to populate all inputs into the MCC Model with robust estimates of local data.

DfT’s recommendation is that local values should be used where possible, but it goes on to advise that either all local values are used, or all default values, and recommends against mixing local and default values. There may be justification for this view where, perhaps, robust local values are only available for one of the input variables, but in our view it would be misconceived to reject all local values simply because data is not available for one of the variables. Objectively, it would be better for the source of each input variable to be selected purely on the relative merits of the alternatives, although it is recognised that a “mix and match” approach could tempt interested parties to select only a combination of values that is perceived will optimise their own respective positions.

It is unfortunate that in weighing up the strengths and weaknesses of alternative input values, there is little information about the provenance of some of DfT’s own default values. However, it is known that the default value of bus speeds in PTE areas is based on analysis of published timetable information in small and medium sized towns, and specifically excludes PTEs. Comprehensive alternative data on bus speeds is not readily available to **pteg**, but bus speeds have been estimated from survey data in one or two PTE areas for some operators. This data has given significantly higher average speeds than the DfT defaults, which is a conclusion corroborated by equivalent data supplied by the bus operators. This casts some doubt on the robustness of DfT’s default values, which as shown above would result in calculated marginal capacity costs being in significant error.

# Definitions of local variables

There a number of specific issues that may arise in identifying robust values for local variables.

Time periods of data: if additional capacity needs to be provided by operators to accommodate generated concessionary passengers, then logically, the data used to calculate the associated cost should relate only to the period during which the concession is available e.g. should exclude weekdays prior to 9:30 am if the there is no discretionary extension to statutory times for the concession. The ability to differentiate between pre- and post-9:30 am services and journeys will be determined by survey procedures, if it is possible at all, and some approximation is likely to be necessary.

Calculation process for average commercial fare: one of the most sensitive inputs into the MCC calculation is the average fare paid by commercial passengers, which is used to net-off the impact that higher service levels might have on commercial revenues against the gross additional costs incurred. The value of this variable can determine whether there appears to be a case for significant marginal capacity costs, or none at all.

In principle, the most satisfactory basis for calculating this figure is probably a reported value of total commercial revenue (excluding reimbursement payments for concessionary passengers) divided by a best estimate of total commercial passenger journeys. However, great care is needed to ensure that both of these values are estimated on a consistent basis. In particular, revenues need to include both on-bus and off-bus revenue, while scrutiny may be required of operator estimates of passenger journeys if these cannot be estimated from independent surveys. Operator estimates of usage of discounted tickets are likely to rely on “rule of thumb” values for the average number of passenger journeys made with each ticket sold, while the reliability of ETM records of passenger journeys (i.e. “button presses”) will be heavily dependent upon operational issues such as driver discipline.

Exclusion of non-generated concessionary journeys from generated revenue calculation: at a detailed level there is a clear logical flaw in the one aspect of the current MCC calculation. “Commercial journeys as a percentage of total journeys” provides the basis for estimating how much additional revenue the operator would earn from running additional capacity (to accommodate generated concessionary passengers). But this will exclude changes in the volume (and hence revenue forgone) of non-generated concessionary passengers. In the counter-factual, the volume and hence revenue from non-generated concessionary passengers will be determined by service levels in exactly the same way as passenger volumes and revenues from commercial passengers. Consequently, in our view the value that should be input into the “revenue gain” element of the MCC calculation should be based on the volume of commercial passengers plus the volume of non-generated concessionary passengers. Since the Reimbursement Factor necessary to estimate this amount from observed concessionary passengers has already been established during the prior calculation flow, it would not be difficult to ensure that gains in revenue forgone are properly accounted for.

# Other Inputs into the Marginal Capacity Cost Calculator

In addition to the values of local variables identified above (which all, in principle, should be specific to an individual operator), the Calculator also requires values to be supplied for some other key parameters, although it is unlikely that most TCAs would have the data to support alternative values to those recommended by DfT. These inputs are as follows:

* Unit costs (per vehicle hour and per vehicle kilometre) – the default values were a key output from the ITS research. The Guidance notes that “although data on vehicle costs may be readily available from operators’ accounts, it is not straightforward to estimate a true marginal cost.” There are no strong grounds for criticising the default values, and it is suggested that default values are applied unless it becomes apparent that they are not appropriate in a particular situation.
* Service elasticity (demand response to service change) – DfT’s recommended value is based on a review of empirical evidence, but operators have consistently claimed that the default value is significantly inaccurate. The role of the parameter in the calculation is to identify the additional commercial patronage (and hence fare revenue) that may have been attracted to the operator by enhanced services put on to accommodate generated concessionary passengers. This is one topic on which DfT is known to have commissioned research to review the evidence, but the outcome of the work is not yet clear. Some PTEs have seen reports from operators that purport to demonstrate that lower service elasticities can be justified, but the quality of evidence appears flimsy.
* Mohring Factor (vehicle miles and demand) – this parameter is also contentious, partly because there is very little empirical evidence to quantify the extent to which operators adjust service levels to reflect changes in demand levels. However, PTEs are uniquely able to shed light in this issue through analysis of continuous survey data, which also provides an alternative methodology for estimating marginal capacity costs. This is discussed below.

# Alternative approaches to analysis of marginal capacity costs

The fundamental rationale for reimbursement for marginal capacity costs is to provide compensation for the cost of providing any additional capacity necessary to accommodate generated concessionary passengers. But a striking feature of the literature on additional costs is the absence of a strong evidence base that quantifies the relationship between the service levels that bus operators choose to supply and the demand that they are trying to accommodate. This is surprising since one would expect that the deregulated environment in Great Britain outside London would provide a clear demonstration of the extent to which changes in passenger demand lead operators to change service levels. As it is, DfT’s Marginal Capacity Cost Model relies upon the value of a parameter known as the Mohring Factor, named after the economist who first identified its value during academic research in the US in the early 1970s. DfT’s recommended value is very largely based on theoretical studies, and assumes that a 10% increase in passenger demand would lead operators to increase service levels by 6%.

A practical reason for this lack of evidence is that for TCAs, and even for bus operators, it is very difficult to observe bus services at a sufficient level of detail to allow meaningful analysis of supply and demand relationships. In addition, it seems that bus operators do not articulate explicit policies that reflect their commercial judgements about how much unused capacity is affordable, and to what extent passengers should have to put up with crowded conditions. In the absence of clearly articulated service planning policies, actual service provision will be the outcome of a series of incremental, tactical decisions about changed frequencies which will be such that the relationship between the maximum load and the legal capacity of individual buses will be extremely varied, and volatile.

However, the data collected by some PTEs does provide an opportunity to observe the level of crowding on board buses at an individual service departure level. Detailed procedures vary, but in at least two PTEs, the boarding and alighting points of all bus passengers are established, together with their ticket type. Consequently it is possible to build up a loading profile for each bus showing the number of passengers on board at each stage. By relating the peak load to the capacity of the bus, it is possible to identify how “crowded” the bus is, and also to identify the number of concessionary passengers contributing to the peak load. At an operator or network-wide level, this enables the frequency with which bus services are “crowded” to be estimated, giving a snapshot of current *de-facto* planning policies. It is reasonable to assume that in the counter-factual, the operator would apply identical policies to achieve the same *de-facto* level of crowding with a reduced number of service departures . The difference between the levels of service in these two situations can then be inferred to be the amount of additional service provided to accommodate generated concessionary passengers, and hence can be used to estimate marginal capacity costs.

It is recognised that the practical capacity of a bus is not absolutely well defined. In legal terms, an operator should not allow more passengers on board than its licensed seating and standing capacity, and even though there may be circumstances in which the legal limits are breached, these are likely to be exceptional. However, in practice, many passengers are likely to regard buses that have significantly fewer people on board than the legal limit as being “full” or “nearly full”. The context is one in which on average, loads tend to be significantly less than the legal limit.

Figure 3 illustrates a typical distribution of peak loads relative to capacity[[19]](#footnote-19). This draws on analysis of over 7,000 individually surveyed bus departures, from all operators in one PTE for all time periods, during 2009-10. The horizontal axis represents different levels of “crowdedness”, measured from the peak load (on each surveyed bus departure, at the peak load point) as a percentage of the licensed seating capacity. The vertical axis represents the percentage of buses observed at different levels of crowdedness or more. Clearly, all bus departures have a peak load that is not less than zero percent of the seating capacity; at the other end of the scale, only a very small percentage of departures exceed 100% of the licensed seating capacity.



**Figure 3 Frequency distribution of bus departures with different levels of peak load**

Overall, it is clear that the majority of bus departures have peak loads that are significantly less than the nominal seating capacity, and even fewer are near the total capacity including standees. While the peak load exceeds 50% of seating capacity in 35% of cases, the corollary is that the peak load is less than 50% in 65% of cases. However, the finding that on average loading levels are modest is not surprising, given that the data reflects all bus services, running throughout the day and into the evening, and on Sundays as well as on weekdays and Saturdays. The fact that bus services typically have to operate in both directions, even when the passenger flow is strongly tidal, will also reduce average loads considerably.

In itself, Figure 2 could be regarded as a summary of bus operator “planning policies” with regard to matching the supply of bus services to demand. It is a “revealed” outcome: in other contexts (such as a more regulated environment) planning policies might be expressed in terms of the objective that, for example, no more than 10% of service departures should have a peak load that is greater than 80% of bus seating capacity[[20]](#footnote-20). We are not aware of commercial bus operators articulating their policy with regard to crowding in this way, but however their policies are expressed or implemented, the outcome can be described in terms of the observed frequency distribution, which could be regarded as an equilibrium position[[21]](#footnote-21).

If Figure 2 is representative of the outcome of historic operator capacity decisions, it becomes possible to use it to assess the outcome of counter-factual scenarios in which demand is varied. Suppose concessions were not available, and demand fell to reflect the absence of generated passengers. It is reasonable to assume that bus operators would adjust the volume of services that they provide until the frequency of crowding returned to the observed equilibrium level.

Because the passenger surveys identify the ticket type use (and in particular whether a passenger is concessionary), the peak load on each surveyed bus can be recalculated with the number of concessionary journeys reduced to “non-generated” levels, by applying the Reimbursement Factor. Clearly, the number of buses for which the peak load exceeds capacity will fall; the difference can then be taken as an estimate of the number of additional buses operated to accommodate the generated passengers.

As discussed above, an arbitrary assumption is required about what is meant by “crowded”. The analysis reported here used alternative definitions, based on a percentage of the licensed seating capacity. The capacity thresholds selected were 85%, 100% and 115% of the licensed seating capacity. The highest threshold (115%) is approaching the physical capacity of some buses, although it is likely still to be much less than the total capacity of many modern buses with high standee numbers. At the other extreme, the lowest threshold (85%) probably reflects perceptions of “fullness” on the part of many concessionary passengers, implying that most seats will be occupied.

Figure 4 shows the “tail” of the frequency distribution, on an exaggerated scale, to show how taking out generated concessionary passengers reduces the number of buses that might be regarded as crowded. The axes are as in Figure 3, but the distribution is only shown for the small proportion of buses in which the peak load exceeds 80% of seating capacity and more.



**Figure 4 Distribution of frequency of crowded buses, with and without generated passengers**

The top line shows the observed frequency distribution: so for example, the data demonstrates that overall, bus frequencies are such that 7% of service departures have a peak load equal to or greater than 85% of the seating capacity. The surveys show that only 3.5% of services would exceed this level of crowding if generated concessionary passengers were not carried. Our assumption is therefore that in the counter-factual, service levels would be reduced so that the level of crowding returned to the observed 7%. The effective cost saving would therefore be that associated with 7% - 3.5% = 3.5% of service departures.

At different “capacity thresholds”, the difference between the number of crowded journeys with and without generated passengers is less: so at 100% of seating capacity, it is 3% - 1.3% = 1.7%. Choice of capacity threshold is currently somewhat arbitrary, but our feeling is that 85% is a not unreasonable judgement. Social research that, for example, used stated preference methods to establish concessionary passengers’ tolerance to different levels of crowding, would be a more satisfactory way of determining the appropriate threshold value.

If the difference between the number of crowded buses, with and without generated concessionary passengers, is taken as a reasonable measure of the scale of additional services associated with generated passengers, then it provides a means either of calculating the additional capacity cost directly, or estimating the implied Mohring Factor. Note that the implied Mohring Factor is dependent upon the capacity threshold used to calculate the “with” and “without” generated passengers crowding levels.

This is illustrated in Table 5, which is reproduced from analysis of 2009/10 data for all operators in one area. The average cost per departure has been calculated using DfT unit costs in 2009-10 prices and local data on route length and average speed. Three alternative sets of calculations are shown, reflecting alternative assumptions about the capacity threshold: obviously, if this is relatively low compared to the licensed seating capacity, then the frequency with which buses will be observed with maximum loads at or over this threshold will increase, and vice versa if a very high threshold is set.

|  |  |
| --- | --- |
| **Data for calculation of Indicators** | **All Bus Operators** |
| Average cost per departure | £19.07 |
| Passenger numbers with generated passengers | 233,945 |
| Passenger numbers without generated passengers | 192,484 |
| Estimated generated passengers | 41,461 |
| Generated passengers as % of total | 21.5% |
| Capacity threshold as % of seating capacity | 70% | 85% | 100% |
| Additional bus departures | 496 | 271 | 134 |
| Gross cost of additional bus departures | £9,456.69 | £5,166.86 | £2,554.83 |
| **Gross cost per generated passenger (2009-10 prices)** | **£0.228** | **£0.125** | **£0.062** |
| Additional bus departures as % of total | 6.6% | 3.6% | 1.8% |
| **Mohring Factor** | **0.306** | **0.167** | **0.073** |
| **Table 5 Additional Capacity Cost Indicators** |

Taking an 85% capacity threshold as a reasonable network-wide value, the calculated gross cost per generated passenger works out at about 12.5 pence per generated passenger. However, this value does not take account of the additional commercial revenue encouraged by the additional capacity provided to accommodate the generated concessionary passengers. If this is allowed for, the additional revenue more than outweighs the additional costs, implying that there are zero net additional capacity costs.

Another way of interpreting the output from the analysis is in terms of an estimate of the Mohring Factor. In this data set, about 21% of all passengers can be considered to be generated concessionary passengers. So at an 85% capacity threshold, these lead to 3.6% more service departures, implying a Mohring Factor of about 0.167 – in contrast to the default DfT value of 0.6. Even with the most generous assumption about capacity thresholds, the Mohring Factor is only about a half of the default value recommended by DfT

Similar results have been reproduced through analysis of data from other PTEs. It is recognised that the nature of the analysis is very data-intensive and is not a practical option for routine calculation of marginal capacity costs for the majority of TCAs; even some PTEs do not have data that is sufficient to carry out this sort of analysis. However, where available, this data provides a unique opportunity to observe the relationship between demand and supply of bus services at a detailed level. So far as we are aware, it is the only analysis that can fully reveal how bus operators trade-off, at one extreme, the provision of significant surplus capacity at some times and places, and at the other extreme, a small proportion of operated services which are very crowded and on which peak loads are close to or at the physical capacity of the operated buses.

The implied Mohring Factor is a simplistic device for summarising this relationship. The values of the Mohring Factor that can be calculated from this detailed analysis suggest that, with regard to changes in the volume of concessionary passengers, appropriate values for concessionary travel reimbursement are much less than those recommended as default values by DfT. As DfT itself notes, the default values are largely based on theoretical studies (which in our view are largely irrelevant to the context of concessionary travel reimbursement in England), whereas the values reported here appear to be the only empirical evidence available on this important component of reimbursement calculations.

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**APPENDIX 1 CHECKLIST OF ISSUES AS AT SEPTEMBER 2013**

| **Issue** | **Current DfT Guidance** | **Summary of concern/issues** | **Nature of supporting evidence/argument**  | **Source and currency of experience** |
| --- | --- | --- | --- | --- |
| ***Average fare calculations*** |
| Process for updating and expanding scope of look-up tables | Guidance encourages TCAs to use their own smartcard data to construct area-specific look-up tables | DfT needs to endorse a mechanism for widening the scope of the look-up tables incorporated into the Calculator. Individual PTEs without their own look-up tables can then draw on data from other PTEs with less risk of criticism of being “off-Guidance” | Research carried out for DfT in 2011 by MVA Consultancy, but not published by DfT, suggests an appropriate mechanism, and also established enhanced and updated look-up tables | Both Centro and Nexus have now constructed their own look-up tables. It would be desirable for other PTEs, which wished to use them, if they were “approved” by DfT in some way.  |
|  |  | Operator arguments that different look-up tables should apply e.g. because their services are “more NoWcard-like” | In principle, it is likely that different discount factors would apply to e.g. out-County passholders. But while passholder travel frequencies might be different, so too will the fare offer. Some further exploration of these issues would be useful. |
| Principles of the Discount factor method | The Guidance provides a detailed rationale for the calculation sequence | The logic behind some of the steps in the sequence appears weak or flawed, partly because of lack of clarity of principles | Discussion of the detailed methodology | Research for Transport Scotland has developed a stronger conceptual rationale for the method which exposes some of the shortcomings of the current calculations |
| Detailed implementation of the method | As exemplified by the DfT Reimbursement Calculator | There appear to be errors in how calculations are carried out regarding the application of “degeneration”, and how the final discount factor is calculated | Diagnosis of the detailed arithmetic coded into the spreadsheet | Previous ***pteg*** correspondence with DfT, supported by GMPTE examples. |
| Outcome of the application of the discount factor method with example PTE data | As above | The discount factors calculated using example operator price data leads to discount factors that appear to be too low, leading to inflated average fare values | Comparison of calculated average fares and equivalent basket of fares calculations. The issues/errors identified above are likely to contribute to the apparent bias in the current method | Nexus data, also supported by recently published Scottish research, and average fares quoted by operators in an additional cost context |
| Need to adapt method to wider range of commercial ticket types | Current guidance restricts “Discount factor method” ticket types to cash fares, and day tickets and weekly tickets | Smartcard ticket products promoted by operators may not match the three generic ticket types, with the result that the discount factor method does not properly simulate the choice of tickets by passholders in the counter-factual. | Data on commercial operator ticket use | Nexus data from one major operator provides an example of the range of ticket types being promoted, and the issues raised for the discount factor method. |
| Need to distinguish between average cash fare paid by commercial passengers and the average equivalent cash fare of concessionary passengers | Guidance does not recognise that differences in trip lengths will lead to differences in the average cash fare | Greater clarity is required on the definition of the average cash fare, and how that is carried through into the discount factor calculation | Data on commercial and concessionary passenger trip lengths from continuous surveys | Nexus, Merseytravel and probably other PTEs |
| **Average fares overview**: for *the vast majority of TCAs who had no independent data on use of ticket types, the discount factor method is a significant advance relative to a basket-of-fares calculation largely based on operator assumptions. Because of its access to good survey data, Nexus has recently demonstrated that the weaknesses in the discount factor method, as implemented by DfT in 2010, have become more serious. It would be advantageous to PTEs for a review of the discount factor method to be placed on the agenda, and in any case PTEs may wish to review whether their local survey data could be used to populate basket-of-fares type calculations.**It is worth noting that various issues associated with average fares impact on all aspects of the current reimbursement calculation (including the determination of the Reimbursement Factor and Additional Costs). Similar data and definitional problems arise in all three applications, and DfT should take a much more holistic approach that is consistent across these three areas.* |
| ***Reimbursement Factor Calculations*** |
| Concept of Reimbursement Factor calculations based on changes in commercial fares from 2005-6, and not related to actual fares in the reimbursement year | Guidance sets out a brief rationale  | Arguments flimsy and not otherwise supported. Not consistent with NB/NW principles. Not consistently applied within Calculator (e.g. to average fare “degeneration”).  | Issues easily demonstrated by hypothetical example | ***pteg*** set out these arguments to DfT following the publication of the “final” (post-consultation) Guidance |
| Source of data on changes in fares | Guidance emphasises that preference (and all logic) is for local data on changes in local fares | Local values for change in fares extremely difficult to source and not meaningful in some circumstances. Guidance gives no definition of what is meant by “average fare” for the purposes of this comparison. | Issues and wide range of competing interpretations can be demonstrated from operator arguments and PTE continuous surveys | Issues fully exposed in Nexus negotiations with operators leading to 2013-14 voluntary agreement; Centro can also demonstrate the practical difficulties of calculating the “change in fares” |
| Calculated RFs are partly determined by historic values of the “average 2005/6 commercial fares” in PTE and non-PTE areas which are not properly defined and have no clear provenance | Values used are not stated in the Guidance nor is there any indication of the source of these values | It is highly unsatisfactory that the values are not exposed and that there is no indication of their origins. | The correctness or otherwise of the values (which can be identified within some of the Calculator formulae) is not known. It would be desirable to establish a robust independent estimate of the average 2005-6 commercial fare in PTE areas. | PTEs are likely to have access to the necessary data from historic reimbursement arrangements. |
| National data on changes in fares may be in conflict with PTE data | Guidance recommends default values based on National data in certain circumstances (e.g. major changes in local bus network) | Operators likely to argue that National data should be used. Not clear how national fares index for PTE areas would compare with PTEs own data where available  | Data on changes in fare levels based on continuous surveys | Issue exposed in Nexus negotiations with operators leading to 2013-14 voluntary agreement |
| Different Reimbursement Factors for different classes of concessionary passengers  | Not referenced | Operator argument | No evidence of different elasticities between different groups, and in any case overall principle of RF calculation is that elasticities are for concessionary passengers as a whole. |
| **Reimbursement factor calculation overview**: *the adoption of the current Guidance method whereby the RF is based on the change in fare from 2005-6 seems to have been a last-minute pragmatic judgement by DfT.**Despite its conceptual flaws, and the great scope for argument created by how it has to be put into practice, it may have led to less variation in outturn RF’s and hence contributed to the widespread acceptance of the new Guidance from 2011-12. Operators have sought to use the practical difficulty of measuring the change in fare from 2005-6 to argue for higher reimbursement levels. PTEs should examine the scope that their own data sources provide for producing their own independent estimates. PTEs also need to be prepared for operators to argue that the conceptual basis for the current method is flawed, if they believe that to be in their interests.* |
| ***Additional costs*** |
| Principles of capacity cost calculations | As set out in Guidance | Counter-intuitive result that capacity costs are higher with lower average load factors | Easily demonstrated by hypothetical examples applied to Calculator | Effect is not dependent upon local values, although scale of impact will be determined by local input data |
| Values of Mohring Factor*(included in this list for completeness)* | Guidance sets out recommended values, which are a topic of current DfT research | Source of current values not relevant to CT reimbursement in deregulated bus network, when more appropriate values have been derived from PTE data | Analysis of PTE survey data allows the relationship between supply and demand to be quantified  | Nexus (2012-13) and GMPTE (2011-12) analysis |
| Values of Service level Elasticity*(included in this list for completeness)* | Guidance sets out recommended values, which are a topic of current DfT research | Concerns have only been raised by operators |  | It would be useful to know if any PTEs have carried out analysis of local data (in a non-CT context) that could provide some additional evidence on this topic |
| Exclusion of non-generated concessionary passengers from revenue gains associated with additional capacity | Current Guidance restricts calculation to commercial journeys only | Non-generated concessionary journeys would also be influenced by changes in capacity in the counter-factual, further increasing revenue gains from additional capacity | Logical flaw in current Guidance, easily demonstrated through hypothetical example | Scale of impact likely to be dependent on local values of input data |
| Scope for debate about definition of some of the local data inputs | Current guidance vague on definitions | Ambiguity creates major source of argument because outcomes are highly sensitive to some inputs (particularly the “average fare” used for determining commercial revenue gains from additional capacity) | Alternative interpretations of Guidance can be easily demonstrated by example | Recent Nexus negotiations |
| Time period to be used for calculation of inputs | Current Guidance unclear | Not clear whether some or all of the local values should be calculated only for those times of day when the concession is in operation (i.e. excluding weekday am peak) or 24/7 | Need for consistency and avoid scope for operators to pick and mix. However, may be academic where PTEs do not have access to sufficiently detailed data to derive local values | Recent Nexus negotiations show implications of data calculated using alternative assumptions |
| Additional cost overview: *although the recommended additional cost methodology can be criticised quite easily, both on theoretical grounds and from the practical perspective of being highly sensitive to input values, the method does provide a helpful focus for discussions on additional costs.* *It is clear that PTE data sources from continuous surveys can offer some extremely important ways of validating operator assertions about input values, and in some cases (e.g. trip lengths) only PTEs are likely to be able to access plausible alternatives to DfT default values.**The biggest current uncertainty is the outcome of DfT’s current research into the Mohring Factor and service elasticities; changes in current values that favour higher additional cost estimates will exacerbate the above issues, whereas changes that reduce additional cost estimates (which is a possible outcome) will reduce their significance.* |
| ***DfT Calculator spreadsheet*** |
| Overall structure and philosophy | The recommended Excel spreadsheet | Use of macros creates unnecessary level of complexity and uncertainty | PTEs have developed alternative spreadsheets which exactly replicate the DfT Calculator but which address most of these issues. They demonstrate that the calculation process can be far simpler and more transparent than the implementation of identical concepts in the DfT Calculator[X] |
|  |  | Fragmentation of reimbursement calculation into many distinct worksheets creates unnecessary complexity |
|  |  | Imbedding of look-up references in formulae to identify parameter values creates excessively long expressions which are very difficult to interpret and audit |
|  |  | Structure does not lend itself to testing of alternative reimbursement scenarios e.g. for different operators, years, datasets etc |
|  |  | These structural issues create significant problems in satisfactorily auditing the DfT spreadsheet as a whole |
| Overview of Calculator Spreadsheet issues: *although it is easy to demonstrate how the current Calculator could be significantly improved, it is unlikely that DfT will explicitly acknowledge these problems. However, there may be a willingness to address some of these issues. If* **pteg** *uses discussion on the methodological issues outlined above to provide access to a version of the “****pteg*** *Calculator”, it is possible that the DfT technical staff carrying out calculations might be persuaded of the merits of a different approach in future versions of the DfT spreadsheet.* |

**APPENDIX 2 REFERENCES**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Title | Author/organisation | Date | Status |
| 1 | Concessionary travel for older and disabled people: guidance on reimbursing bus operators (England) | Department for Transport | November 2013 | Published on DfT website |
| 2 | Review of Look-up Tables from Centro Smartcard Data | Andrew Last/Minnerva Ltd | 17/2/2014 | Research for TfGM - unpublished |
| 3 | Provision of Look-up Tables for DfT Concessionary Travel Reimbursement Calculator | MVA Consultancy and Minnerva Ltd | 18/5/2012 | Unpublished research for DfT |
|  |  |  |  |  |
| 4 | File Note: Principles and application of DfT “Discount Factor Method” | Minnerva Ltd | 16/4/2014 | Unpublished file note for ***pteg*** |
| 5 | Calculating Average Commercial Fares for Concessionary Travel Reimbursement | Minnerva Ltd | 17/8/2010 | Unpublished case study for ***pteg*** based on GMPTE data |
| 6 | File Note: Differences in the journey length distributions of users of different ticket types | Minnerva Ltd | 17/4/2014 | Unpublished file note for ***pteg*** |
| 7 | Scotland-wide Older and Disabled Persons Concessionary Bus Scheme – Further Reimbursement Research | MVA Consultancy in association with Minnerva Ltd | 7/2/2013 | Published |
| 8 | Bus operator reimbursement: the case for additional capacity costs | Minnerva Ltd | 4/8/2011 | Unpublished note for Nexus |

1. Most recently published in October 2013 for schemes commencing in April 2014. See Reference 1. [↑](#footnote-ref-1)
2. DfT undertook a formal Consultation on draft Guidance dated September 2010, to which ***pteg*** responded in detail. Some significant changes were made in the final version of the Guidance, on which the current version is largely based, but in the ***pteg*** view some of these late changes, on which there was no opportunity to comment, created additional difficulties. [↑](#footnote-ref-2)
3. Reference 1 identifies the principal source of official guidance on reimbursement, published by DfT. [↑](#footnote-ref-3)
4. By complete, we mean having confidence that data on all journeys made by a passholder in a particular day have been captured. Alternative data collection methods such as surveys are likely to under-record days in which a passholder makes no journeys, which are an important consideration in simulating the possible purchase of weekly tickets. [↑](#footnote-ref-4)
5. The Centro look-up table is documented in Reference 2. [↑](#footnote-ref-5)
6. It is important to note that these values are unlikely to be comparable with average journey frequencies that might be calculated from conventional survey data, because of the exclusion (from the look-up table) of weeks in which no journeys are made. [↑](#footnote-ref-6)
7. E.g. paragraph 6.11 [↑](#footnote-ref-7)
8. Reference 3 [↑](#footnote-ref-8)
9. Reference 2 describes work on behalf of TfGM which examined the case for use of the Centro–derived look-up table in the Greater Manchester area, and provides an illustration of some of these issues. [↑](#footnote-ref-9)
10. “Degeneration” is used by DfT to describe the process through which look-up table results, based on observed free concessionary journey volumes, are adjusted to represent the journey frequencies that might be expected in the counter-factual, without journeys generated by the free concession. [↑](#footnote-ref-10)
11. Reference 4 [↑](#footnote-ref-11)
12. Reference 5 [↑](#footnote-ref-12)
13. The balance of arguments on theoretical grounds between the “Discount Factor method” and the “Basket of Fares method”, as described by DfT is not clear cut. The Discount Factor method requires arbitrary assumptions to be made about the impact of generation on observed concessionary journeys, whereas the Basket of Fares method requires assumptions about the comparability of passholder and commercial passenger travel and purchasing patterns. The main advantage of the Discount Factor method, which is why it is recommended by DfT, is that it does not rely on external assumptions about journey shares and trips per ticket, which is needed to apply the Basket of Fares methods. But PTEs may have the data to avoid the need to rely upon these assumptions, thus negating the main practical disadvantage of the Basket of Fares approach. [↑](#footnote-ref-13)
14. See Reference 6 [↑](#footnote-ref-14)
15. This is demonstrated in Reference 7 [↑](#footnote-ref-15)
16. Some technical options for more complex choice modelling are available such as multinomial logit, but it is unlikely that these can be readily applied in a practical reimbursement context. [↑](#footnote-ref-16)
17. This reproduces the RF calculation implied by the DfT spreadsheet, and is calculated from Exp(-0.6687\*f0.7232) where f = F5-6 / 1.12, and F5-6 = 1.5\*0.8495. The calculation uses the SDC parameters for PTEs, applied to the fare of £1.50, deflated to 2005-6 prices, and divided by the assumed average PTE fare in 2005-6. [↑](#footnote-ref-17)
18. As illustrated in Reference 6 [↑](#footnote-ref-18)
19. From Reference 8 [↑](#footnote-ref-19)
20. In the past, TfL have explicitly formulated its policies for bus provision in these terms. [↑](#footnote-ref-20)
21. We believe an equilibrium assumption is reasonable for the area from which this data was taken and at the time in question. Clearly, some degree of “churn” is inevitable, with various operators losing or gaining market shares, but this is unlikely to significantly affect the picture at a network wide level, across all operators. [↑](#footnote-ref-21)